NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(213)
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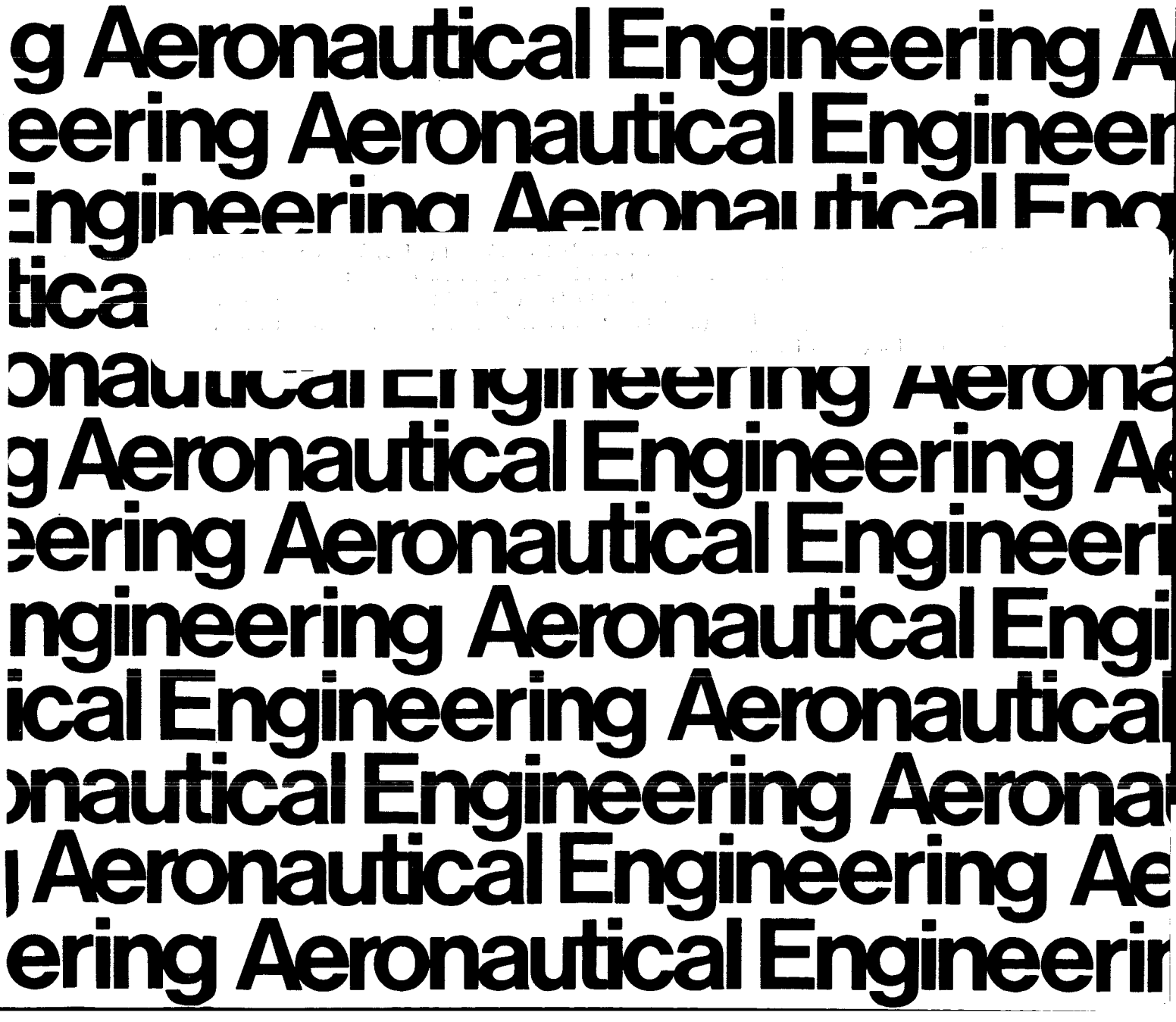
National Aeronautics and Space Administration



NASA SP-7037(213) Aeronautical Engineering Pages 211-274 May 1987

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NASA SP-7037(213)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 213)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in April 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 423 reports, journal articles and other documents originally announced in April 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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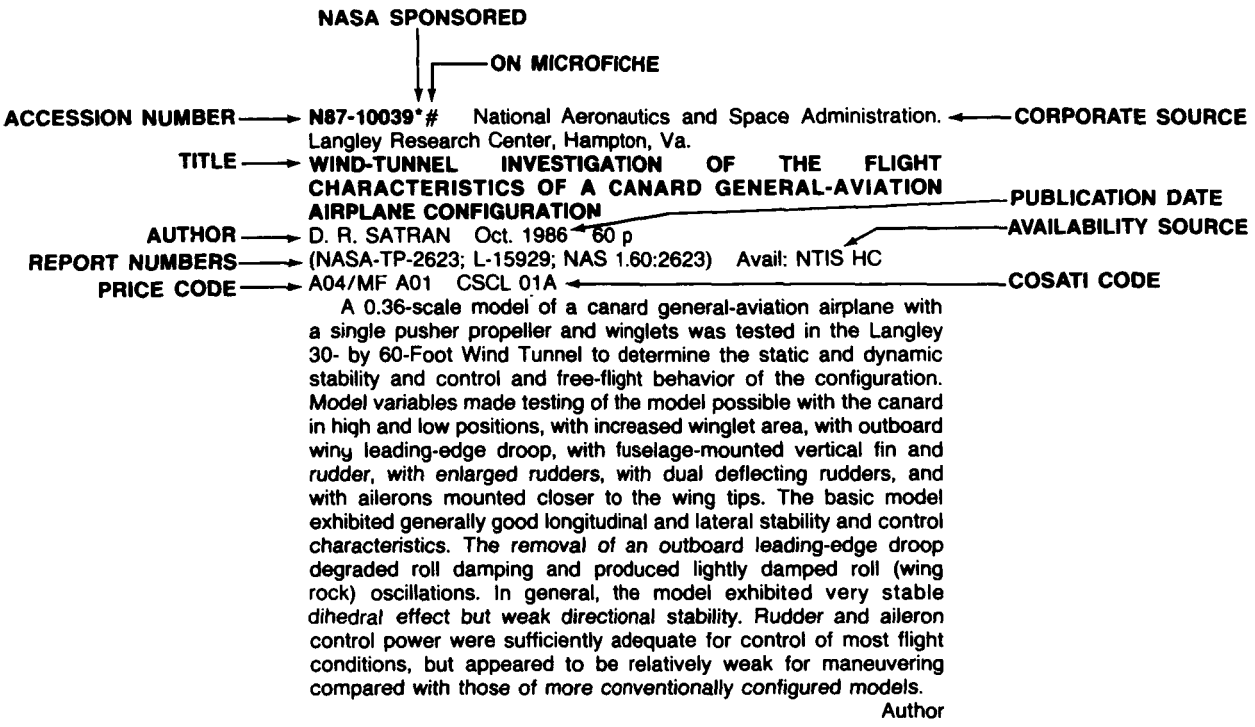
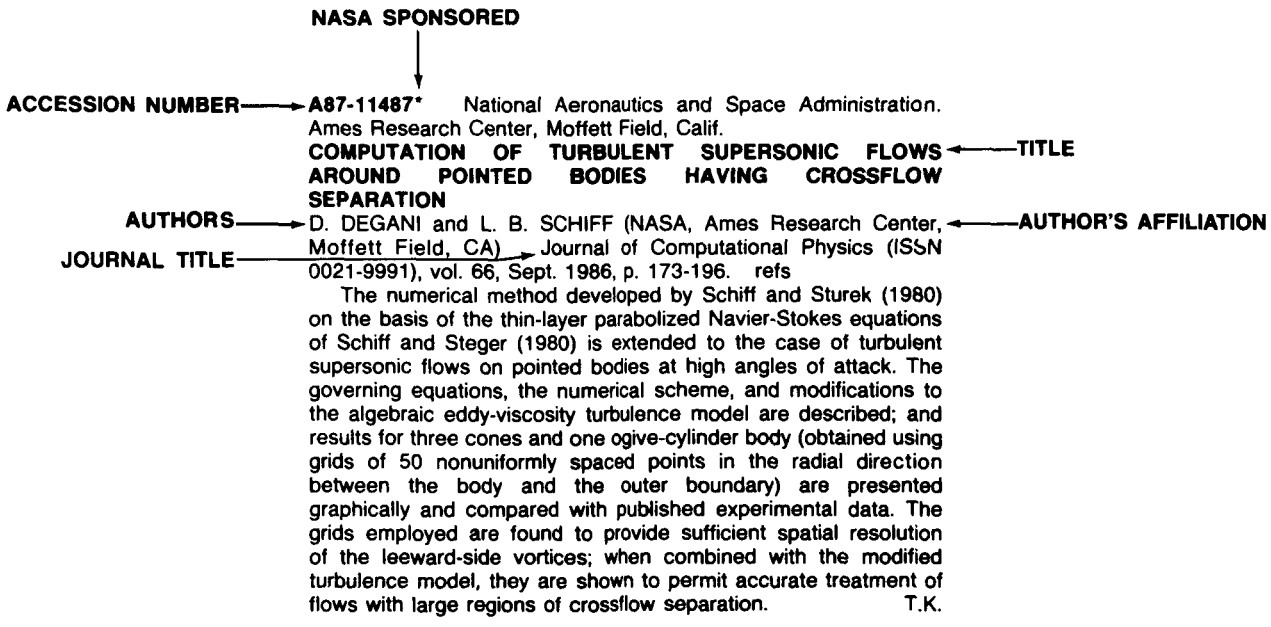


TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 213)

MAY 1987

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AERONAUTICS (GENERAL)

A87-20938
THE SYSTEM CONCEPT AND THE DESIGN ENGINEER
WELKO E. GASICH (Northrop Corp., Los Angeles, CA) Aerospace Engineering (ISSN 0736-2536), vol. 6, Oct. 1986, p. 47, 48, 51, 52, 55.

In the course of developing jet fighters and guided missiles, engineers discovered that many more design variables had to be considered than in the past and that the interactivity among major systems of a given aircraft or missile had grown considerably. The increasing availability of computational resources then opened prospects for the internal communication of aircraft and missile systems by way of an airborne computer. An account is presently given of the development history and characteristic concerns of systems engineering. O.C.

A87-21287
DESIGN FOR LOW COST
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 130, Sept. 27, 1986, p. 31-33.

Case histories are presented to illustrate the thesis that the achievement of low costs in aerospace products manufacture has its indispensable basis in the design of components which can be straightforwardly fabricated by techniques that have been proved to be feasible and are readily available. Novel materials and processes can involve cost pitfalls; intended economies in labor, parts number reductions, and quality repeatability, must be fully realizable at the outset. Attention is given to cost benefits derivable from a flexible manufacturing system's computer-controlled production lines. O.C.

A87-21863
REPAIR OF AIRCRAFT AND HELICOPTERS [REMOUT SAMOLETOV I VERTOLETOV]
K. IA. ORLOV and V. A. PARKHIMOVICH Moscow, Izdatel'stvo Transport, 1986, 296 p. In Russian. refs

The basic principles and methods of the maintenance and repair of aircraft and helicopters are presented. In particular, attention is given to the organization of maintenance and repair processes, production and control documentation, quality assurance, and ground and flight testing. The diagnostic techniques discussed include visual identification of defects, capillary methods, magnetic inspection techniques, defect identification by the eddy current method, acoustic, radiographic, electronographic, and other methods of nondestructive evaluation. The discussion also covers defect classification methods for repairing specific aircraft components. V.L.

A87-22223
KEEPING THEM FLYING
PAUL WALLICH IEEE Spectrum (ISSN 0018-9235), vol. 23, Nov. 1986, p. 69-75.

Except for unscheduled repairs, commercial aircraft maintenance procedures take the form of a series of inspections requiring increasing diligence on the part of the groundcrew; these are designated A, B, C, and D. The C and D checks often require that the airliner be taken out of service for a period of between one week and one month, and are conducted one every 3500 and 15,000 flight hours, respectively. A and B checks are respectively scheduled one every 250 and once every 500-600 flight hours. It is feared that airliners occasionally ignore maintenance problems in order to honor flight schedules. Improper maintenance procedures caused the crash of a DC-10 airliner in 1979. O.C.

A87-23296#
ENGINEERING ECONOMIC ANALYSIS OF BREAKEVEN IN AIRCRAFT PRODUCTION
HUIMIN YE Northwestern Polytechnical University, Journal, vol. 4, Oct. 1986, p. 423-429. In Chinese, with abstract in English. refs

Aircraft production is technology intensive and requires expensive material and equipment, dictating large amounts of non-recurring investment. In an environment of strong market competition, a long period is required to reach breakeven in aircraft production. Assuming continuous cash flows and continuous compounding interest, a mathematical model is presented for the calculation of the aircraft breakeven point. A learning curve pattern that is exhibited in aircraft serial production is used in the model. Results are generated in the form of a continuous function, thus facilitating the selection of major influencing factors in the sensitivity analysis of breakeven and providing the logical foundation for making the economic decision in the aircraft conceptual design stage. Author

N87-15165# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
TRANSITION FIXING ON WINGS IN INDUSTRIAL WIND TUNNELS AND ASSOCIATED PROBLEMS
V. SCHMITT *In* ESA Bounday Layer Control by Transition Fixing (ESA-TT-909) p 81-88 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984
Original language document was announced as N85-23717
Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

A method for transition fixing on wings, based on the utilization of carborundum strips to produce an homogeneous turbulent boundary layer is presented. The choice of strip position and grain size is explained. The transition is visualized by thermography using an IR camera. The influence of the transition fixing is demonstrated. Problems in scaling the simulation results for high Reynolds numbers to large aircraft are discussed. ESA

N87-15933# Naval Postgraduate School, Monterey, Calif.
AN ANALYSIS OF THE COST-VOLUME RELATIONSHIPS WITHIN THE AIRCRAFT PROGRAM OF THE NAVAL AIR REWORK FACILITY, ALAMEDA, CALIFORNIA M.S. Thesis
ROBERT L. FERRIMAN Jun. 1986 128 p
(AD-A171729) Avail: NTIS HC A07/MF A01 CSCL 14A

The purpose of this research project is to examine the cost behavior of the Naval Air Rework Facility, Alameda, California, aircraft program in relation to variations in aircraft rework workloads, and to develop cost-volume relationships useable in support of pricing and workload decisions. Analysis of four years of quarterly direct and indirect cost data provided the base from which total cost-volume models were derived for the four aircraft program segments (A-6, P-3, S-3 and A-3). The results of this study indicate that significant cost-volume relationships exist not only with direct costs but also with many associated indirect aircraft program costs. The study further suggests that other factors, such as rate and direction of volume changes and levels of personnel strengths, may have predictable affects on aircraft rework costs. GRA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A87-20240
LARGE-SCALE STRUCTURES VISUALIZATION IN A HIGH REYNOLDS NUMBER, TURBULENT FLAT-PLATE WAKE AT SUPERSONIC SPEED
J. P. BONNET and E. CHAPUT (Poitiers, Universite, France) Experiments in Fluids (ISSN 0723-4864), vol. 4, no. 6, 1986, p. 350-356. refs
(Contract DRET-82-169-2)

A visual study is performed in a supersonic, two-dimensional wake; the high value of the Reynolds number ensures that the wake is turbulent from the trailing edge. The flow is seeded by fluid vaporization in one boundary layer upstream of the trailing edge; a light sheet is generated by a Q-switched, high energy ruby laser. The set of photographs taken from the trailing edge up to the far wake is then processed after digitization of the pictures. A progessive contamination of the lower part of the wake by the fluid initially present in the upper part can be observed. In the far wake region, well organized large scale structures can be visualized. Statistics are performed and the results are compared with previous hot-wire measurements and discussed in terms of downstream wake behavior. Author

A87-20357
TRANSONIC AERODYNAMICS
JULIAN D. COLE (Rensselaer Polytechnic Institute, Troy, NY) and PAMELA L. COOK (Delaware, University, Newark) Research supported by the U.S. Air Force and NSF. Amsterdam and New York, North-Holland (North-Holland Series in Applied Mathematics and Mechanics. Volume 30), 1986, 480 p. refs
(Contract F49620-79-C-0162; NSF MCS-80-02203; NSF DMS-84-01738)

The principles of transonic aerodynamics are presented in a self-contained introduction which assumes knowledge of elementary fluid mechanics. The emphasis is on the application of perturbation methods to ideal inviscid flows. Chapters are devoted to linearized theory and transonic breakdown, transonic expansion procedures, transonic far fields, transonic airfoil theory, three-dimensional wings, and quasi-transonic flow. T.K.

A87-20380
CONSTRUCTION OF WING PROFILES ON THE BASIS OF THE THEORY OF INVERSE BOUNDARY VALUE PROBLEMS USING THE METHOD OF QUASI-SOLUTIONS [POSTROENIE KRYLOVYKH PROFILEI NA OSNOVE TEORII OBRATNYKH KRAEVYKH ZADACH METODOM KVAZIRESHENII]
A. M. ELIZAROV, N. B. ILINSKII, and A. V. POTASHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 18-22. In Russian. refs

A new method is presented for satisfying the closure conditions for a wing profile in the inverse boundary value problem in hydro- and aerodynamics. In this problem, an isolated wing profile is constructed on the basis of the velocity distribution specified on its surface as a function of the arc abscissa in the case of plane steady flow of an ideal incompressible fluid past the profile. Results of calculations illustrating the possibilities of this approach are presented. V.L.

A87-20386
A STUDY OF RECIRCULATION REGION BOUNDARIES FOR A TURBULENT JET IMPINGING ON A SCREEN IN EXTERNAL FLOW [ISSLEDOVANIE GRANITS OBLASTI RETSIRKULIATSII PRI NATEKANII NA EKRAN TURBULENTNOI STRUI VO VNESHNEM POTOKE]
Z. V. AKHTIAMOV, M. SH. GILIAZOV, and G. F. MINGALEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 44-46. In Russian.

Experiments were carried out on single air jets issuing from axisymmetric nozzles of 5.5- and 9-mm diameters at 45, 60, and 90 degrees to the surface of a screen and also on air and CO2 jets issuing from rectangular (6.5 x 7 mm) jets of a turbojet engine model at 60 and 90 degrees. The incoming flow velocity in the experiments remained constant at 17.5 m/s. It is shown that, in relative coordinates, the boundaries of recirculation flow for circular and rectangular jets are in satisfactory agreement. It is also shown that the presence of a duct between the turbojet engine and the screen has no appreciable effect on the results, which makes it possible to use the results obtained here for calculating flows in real engines. V.L.

A87-20412
MATHEMATICAL MODELING OF THE OPENING DYNAMICS OF AN AXISYMMETRIC PARACHUTE [MATEMATICHESKOE MODELIROVANIE DINAMIKI RASKRYTIIA OSESIMMETRICHNOGO PARASHIUTA]
I. V. DNEPROV and A. T. PONOMAREV Prikladnaia Mekhanika (ISSN 0032-8243), vol. 22, Sept. 1986, p. 108-113. In Russian. refs

The opening of an axisymmetric impermeable parachute is modeled mathematically using a computer. The algorithm for solving this aeroelasticity problem is based on relationships of nonlinear aerodynamics, Rakhmatullin's elastic model, and data synthesis for different parts of the problem. The separated flow scheme is constructed by using an ideal incompressible fluid mode and the discrete vortex method. V.L.

A87-20504
A HYBRID METHOD FOR TRANSONIC FLOW PAST MULTI-ELEMENT AEROFOILS
M. G. HILL and N. RILEY (East Anglia, University, Norwich, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 170, Sept. 1986, p. 253-264. SERC-supported research. refs

A method for calculating transonic potential flow past a multielement aerofoil configuration is presented. The method is a hybrid method that is based upon a compressible-flow panel method, valid for subcritical flow, and a finite-difference method that is suitable for supercritical flow calculations. The effectiveness of the proposed method is demonstrated, first by application to a single aerofoil and then to a three-element aerofoil. Author

A87-20697#
A NUMERICAL METHOD FOR SUBSONIC UNSTEADY LIFTING SURFACES-(BIS). II - NUMERICAL RESULTS
MASAMI ICHIKAWA and SHIGENORI ADO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 391, 1986, p. 427-435. In Japanese, with abstract in English. refs

A numerical evaluation of a new computation method for unsteady subsonic lifting surfaces, BIS(Box-In-Strip) (Ichikawa and Ando, 1986), is presented. The numerical results of BIS-QS, a refined version, are compared with those of DLM (Doublet-Lattice Method) and DPM (Doublet-Point-Method). Three kinds of wing planform are used for evaluating these schemes. Comparison is made between the pressure distribution at the root chord of a high-aspect-ratio wing and that of two-dimensional airfoil. It is found that the convergence and accuracy of BIS-QS are superior to DLM significantly and to DPM remarkably, without increasing computation cost, even for high frequency and high subsonic Mach number. Author

A87-20800
TWO-DIMENSIONAL FLOW PAST BLUFF FLEXIBLE MEMBRANES OF LOW POROSITY
H. T. LOW and B. G. NEWMAN (McGill University, Montreal, Canada) Aeronautical Journal (ISSN 0001-9240), vol. 90, Oct. 1986, p. 313-334. Sponsorship: Fonds pour la Formation de Chercheurs et l'Action Concertee-Quebec. refs
(Contract NSERC-A-7096)

This paper considers two-dimensional flow past flexible membranes whose supports are aligned at right angles to the flow. Unlike a previous study of bluff impervious membranes, the present membranes are slightly porous having a porosity similar to that of parachutes. The drag and base pressure have been measured for various lengths and for a variety of fabrics. The results have been correlated by two theories which are extensions of those already published. When the porosity is not too small the results are shown to depend only on the total volume flow through the membrane. The tendency for the membrane to oscillate in harmony with regular vortex shedding is reduced by the porosity and increased by the length of the membrane. Above a certain porosity oscillation is inhibited for all membrane lengths. Author

A87-20876*# Old Dominion Univ., Norfolk, Va.
TRANSONIC VORTEX FLOWS PAST DELTA WINGS - INTEGRAL EQUATION APPROACH
OSAMA A. KANDIL (Old Dominion University, Norfolk, VA) and E. CARSON YATES, JR. (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Nov. 1986, p. 1729-1736. Previously cited in issue 19, p. 2746, Accession no. A85-41415. refs
(Contract NAG1-591)

A87-20880#
THEORETICAL AND EXPERIMENTAL DESCRIPTION FOR A RADIAL SUPERSONIC FLOWFIELD
N. L. RAPAGNANI (USAF, Weapons Laboratory, Kirtland AFB, NM) and F. R. ZUMPANO (United Technologies Research Center, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 24, Nov. 1986, p. 1758-1765. refs

A time-dependent, two-dimensional viscous analysis was employed to evaluate the radially expanding supersonic flowfield created by a cylindrical ring-type source nozzle. This complex flowfield is similar to that generated by a line source with oblique shock waves, expansion fans, and embedded wake regions. Comparisons are made between analytical and experimental results for a source-flow nozzle having an exit Mach number of approximately two and using air on the flowing gas. The analytical results are in excellent agreement with the experimentally measured pitot and static pressure distributions obtained parallel to the source-nozzle axis at different radial locations. Author

A87-21021#
PREDICTION OF BUFFETING AND CALCULATION OF UNSTEADY BOUNDARY LAYER SEPARATION OVER AIRFOILS
J. C. LE BALLEUR and P. GIRODROUX-LAVIGNE (ONERA, Chatillon-sous-Bagneux, France) (IUTAM, Symposium on Boundary Layer Separation, University College, London, England, Aug. 26-28, 1986) ONERA, TP, no. 1986-95, 1986, 18 p. Research supported by the Service Technique des Programmes Aeronautiques. refs
(ONERA, TP NO. 1986-95)

The unsteady boundary layer separation is computed using a fully time-consistent viscous-inviscid interaction method. The time-dependent method discriminates between the steady solutions and the unsteady 'buffet' generated by transonic shock-induced separation over a steady lifting airfoil, depending on Mach number and incidence. From the first results, the unsteady pressure distributions display time-histories and spectral properties which compare rather well with buffet experiments, in two-dimensions, providing some hope in further buffeting prediction. Author

A87-21031#
DETERMINATION OF THE CAVITATION REGION IN A ROW OF SUPERSONIC BLADES [DETERMINATION DE LA REGION DE CAPTATION D'UNE GRILLE D'AUBES SUPERSONIQUE]
GEORGES MEAUZE (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Transonic and Supersonic Phenomena in Turbomachines, 68th, Munich, West Germany, Sept. 10-12, 1986) ONERA, TP, no. 1986-112, 1986, 13 p. In French.
(ONERA, TP NO. 1986-112)

The characteristics of aerodynamic phenomena in cavitation regions of a blade row in supersonic compressors are discussed qualitatively. Flow elements normal to the freestream flow are assumed to have subsonic velocity. The streamlines of the freestream flow are determined by solution of the continuity and conservation equations. The independence of upstream and downstream flows is considered, along with the effects of blade geometry, the shapes of the leading and trailing edges of the blades, and the flow curvature. CAD techniques are explored for optimizing blade shapes in high pressure compressors to reduce the effects of shocks. M.S.K.

A87-21032#
AN ANALYSIS OF LOSSES DUE TO SHOCK WAVES [ANALYSE DES PERTES DUES AUX ONDES DE CHOC]
ANTOINE FOURMAUX and ALAIN LE MEUR (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Transonic and Supersonic Phenomena in Turbomachines, 68th, Munich, West Germany, Sept. 10-12, 1986) ONERA, TP, no. 1986-113, 1986, 12 p. In French. SNECMA-supported research.
(ONERA, TP NO. 1986-113)

The results of recent theoretical and experimental work carried out by ONERA to develop blade designs which reduce aerodynamic losses due to shock waves in compressors are summarized. Attention is given to the sources of losses which have been identified, i.e., shock-leading edge interactions, recompression, and interaction of the fluid viscosity with the shock. The experimental apparatus is described, along with inboard and outboard boundary layer pressure data. Finally, data are presented from trials with blades designed to minimize the aerodynamic losses. M.S.K.

A87-21038#
UNSTEADY THREE-DIMENSIONAL STALL ON A RECTANGULAR WING
J. J. COSTES (ONERA, Chatillon-sous-Bagneux, France) (DGLR, European Rotorcraft and Powered Lift Aircraft Forum, 12th, Garmisch-Partenkirchen, West Germany, Sept. 22-25, 1986) ONERA, TP, no. 1986-119, 1986, 24 p. refs
(ONERA, TP NO. 1986-119)

Steady and unsteady stall are studied on a rectangular wing in normal flow. The wing is allowed to oscillate in pitch around the quarter chord. Experiments performed at the S2 wind-tunnel in

Chalais-Meudon with a rectangular wing and a wind velocity of 95 m/s are in good agreement with the results obtained from the theory developed here. Author

A87-21041#
NUMERICAL VISCOUS-INVISCID INTERACTION METHOD FOR INTERNAL SEPARATED FLOW AND SHOCK WAVE-BOUNDARY LAYER INTERACTION [METHODE NUMERIQUE D'INTERACTION VISQUEUX-NON VISQUEUX POUR LES ECOULEMENTS INTERNES DECOLLES ET L'INTERACTION COUCHE-LIMITE-ONDE DE CHOC]
J. C. LE BALLEUR and D. BLAISE (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Transonic and Supersonic Phenomena in Turbomachines, 68th, Munich, West Germany, Sept. 10-12, 1986) ONERA, TP, no. 1986-123, 1986, 21 p. In French. DRET-SNECMA-supported research. refs
(ONERA, TP NO. 1986-123)

A numerical model is presented for internal transonic separated flows and shock wave-boundary layer interactions. A thin layer's approximation is applied within defect formulation theory for integral calculations for viscous flows. An Euler solver is used with direct and semi-inverse strong coupling methods and direct and inverse defect integral methods and generalized turbulence models for the inviscid fields. The results of sample computations for, e.g., turbulent flows in transonic shocked channels with back-pressure, including multiple shock wave-boundary layer interactions and incipient and extensive flow separation, are provided. M.S.K.

A87-21042#
A QUADRATURE-COLLOCATION TECHNIQUE FOR BOUNDARY ELEMENT METHOD - APPLICATION TO HELICOPTER FUSELAGE
J. RYAN and T. H. LE (ONERA, Chatillon-sous-Bagneux, France) (DGLR, European Rotorcraft and Powered Lift Aircraft Forum, 12th, Garmisch-Partenkirchen, West Germany, Sept. 22-25, 1986) ONERA, TP, no. 1986-124, 1986, 12 p. refs
(ONERA, TP NO. 1986-124)

This paper is an extension of the work of Le et al. (1986) on a fast collocation boundary method applied to incompressible inviscid flow. Recent developments are presented, and the reliability of this new technique is shown. Comparison of results is shown for more realistic configurations such as helicopter fuselages with and without wake. Author

A87-21054#
INFLUENCE OF THE STATIC DEFORMATION ON A WING IN THE UNSTEADY AERODYNAMIC
R. DESTUYNDER (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Static Aeroelasticity Effects on High-Performance Aircraft, 63rd, Athens, Greece, Oct. 5-10, 1986) ONERA, TP, no. 1986-152, 1986, 9 p. refs
(ONERA, TP NO. 1986-152)

Wind tunnel tests and related calculations were carried out to study the influence of static deformation (due to steady loads) on the flutter phenomenon experienced by modern civil aircraft. Consideration is also given to the nonlinearity of unsteady forces on an engine as a function of global incidence. It is found that the spanwise untwisting effect associated with positive incidences increases the flutter limits for given Mach number and dynamic pressure values. K.K.

A87-21069#
THE INFLUENCE OF THE CHOICE OF COMPUTATIONAL PARAMETERS ON THE RESULTS OF THREE-DIMENSIONAL POTENTIAL METHODS [ETUDE DE L'INFLUENCE DES PARAMETRES DE CALCUL SUR LES RESULTATS DE METHODES POTENTIELLES 3D]
D. DESTARAC ONERA, TP, no. 1986-169, 1986, 40 p. In French. refs
(ONERA, TP NO. 1986-169)

The effects of the choice of parameters on the results obtained in modeling flows over a wing by two different three-dimensional potential equations are examined. Attention is given to nonconservative finite difference (NCFD) and conservative finite element (CFE) methods. The fineness of the grid mesh and extensions to the domain of computation are considered for subsonic and transonic flows. Sample calculations were carried out for four different meshes. Convergence was enhanced with the CFE method compared to that of the NCFD method. The number of grid points heavily influenced the accuracy of results in the transonic case, for which the two equations gave significantly different results. M.S.K.

A87-21072#
VALIDATION OF TURBULENCE MODELS APPLIED TO TRANSONIC SHOCK WAVE-BOUNDARY LAYER INTERACTION [VALIDATION DE MODELES DE TURBULENCE APPLIQUEES A L'INTERACTION ONDE DE CHOC-COUCHE LIMITE TRANSSONIQUE]
RICHARD BENAY, MARIE-CLAIRE COET, and JEAN DELERY (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-173, 1986, 63 p. In French. refs
(ONERA, TP NO. 1986-173)

Numerical and empirical techniques are presented which can be used to evaluate the accuracy of turbulence models used in numerical models for transonic shock wave-boundary layer interactions (SWBLI). Various SWBLI models are discussed, with emphasis placed on first-order two-dimensional boundary layer approaches. The validity of any model is a matter of using the model to describe turbulence, obtaining errors that are within a range of acceptable accuracy, and performing the calculations rapidly enough to permit multiple simulations. Several algebraic and memory effect models are described which satisfy the validity criteria. M.S.K.

A87-21077#
COMPARATIVE TRANSPORT AIRCRAFT MODEL TESTS IN MANY EUROPEAN WIND TUNNELS [ESSAIS D'UNE MAQUETTE D'AVION DE TRANSPORT SCHEMATIQUE DANS PLUSIEURS SOUFFLERIES EUROPEENNES]
V. SCHMITT (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-178, 1986, 27 p. In French. refs
(ONERA, TP NO. 1986-178)

In an effort to enhance the design capabilities among European aircraft developers, the same tests of the same supercritical wing-body configuration were performed at three wind tunnel installations in Europe. Measurements were made, at Mach 0.78, of the global forces, moments and pressure distributions along the wing and fuselage. The data were analyzed at each installation (HST, S2 Modane, and RAE) and compared. Variations in the angle of attack were below 0.1 deg, drag divergence was less than 0.001, and pitching moment differences averaged under 0.015. Most importantly, the positions of the observed shocks agreed to within 0.05. M.S.K.

A87-21079#
SEPARATION IN THREE-DIMENSIONAL INCOMPRESSIBLE FLOW EXPERIMENTS FOR VALIDATION AND MODELING [DECOLLEMENT EN ECOULEMENT INCOMPRESSIBLE TRIDIMENSIONNEL EXPERIENCES DE VALIDATION ET MODELISATION]
D. BARBERIS and B. CHANETZ (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-180, 1986, 60 p. In French. refs
(ONERA, TP NO. 1986-180)

Measurements were made of turbulent flows around obstacles to provide data for validating numerical models for separated three-dimensional flows. Wind tunnel flows past an axisymmetric ellipsoidal cylinder and an oblate ellipsoidal cylinder were monitored on the lee side by LDV, and streakline photography was used for flow visualization. A finite difference formulation used to simulate boundary layer development is detailed and predictions made with it are compared with the experimental data. Both direct and inverse solution techniques for the finite difference model were found effective for describing the separation line. M.S.K.

A87-21082#
A COMPARISON AND VALIDATION OF METHODS FOR SOLVING THE EULER EQUATIONS [COMPARAISON ET VALIDATION DE METHODES RESOLUTION DES EQUATIONS D'EULER]
M. BORREL, V. COUAILLIER, A. LERAT, J.-L. MONTAGNE, J. SIDES (ONERA, Chatillon-sous-Bagneux, France) et al. ONERA, TP, no. 1986-183, 1986, 29 p. In French. refs
(ONERA, TP NO. 1986-183)

Three finite volume numerical models under development by ONERA for solving the Euler equations for transonic flows are described. The discussion covers an explicit decentralized scheme, an explicit centered and multigrid code for accelerated convergence, and an implicit centered model with artificial viscosity. Governing equations and sample results are provided from use of the models to describe the flowfield around a NACA 0012 airfoil. The introduction of artificial viscosity is found to yield the least accurate results, although use of a centered approach with the implicit method gives results close to those of previous studies of inviscid flowfields. M.S.K.

A87-21083#
THE VALIDATION OF SOLUTION METHODS FOR THE NAVIER-STOKES EQUATIONS FOR A COMPRESSIBLE FLUID - RESULTS OF THE 'GAMM-WORKSHOP' IN NICE [VALIDATION DE METHODES DE RESOLUTION DE EQUATIONS DE NAVIER-STOKES EN FLUIDE COMPRESSIBLE - RESULTATS DU 'GAMM-WORKSHOP' DE NICE]
M. O. BRISTEAU (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), O. LABBE, H. VIVIAND (ONERA, Chatillon-sous-Bagneux, France), and J. PERIAUX (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) ONERA, TP, no. 1986-184, 1986, 34 p. In French. refs
(ONERA, TP NO. 1986-184)

Results are presented from comparisons of several numerical methods for solving the Navier-Stokes for two types of two-dimensional, low-Re flows: external transonic or supersonic flows around a NACA 0012 airfoil; and, internal subsonic and supersonic flows in a double-throat nozzle. The discussion covers finite difference, finite element and finite volume codes, and Lax-Wendroff, MacCormack and Runge-Kutta explicit and linearized, Newtonian, and least squares implicit discretizations. Acceptable accuracy was obtained with all the methods, in comparison with experimental data, although discrepancies were higher for the flow around the airfoil due to the boundary layer treatments used. M.S.K.

A87-21085#
NEW NUMERICAL TECHNIQUES IN THE METHOD OF SINGULARITIES FOR APPLICATION TO COMPLEX THREE-DIMENSIONAL CONFIGURATIONS [TECHNIQUES NUMERIQUES NOUVELLES DANS LES METHODES DE SINGULARITES POUR L'APPLICATION A DES CONFIGURATIONS TRIDIMENSIONNELLES COMPLEXES]
T. H. LE, Y. MORCHOISNE, and J. RYAN (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix-en-Provence, France, Apr. 7-10, 1986) ONERA, TP, no. 1986-186, 1986, 9 p. In French. refs
(ONERA, TP NO. 1986-186)

A singularity method for the analysis of steady irrotational inviscid incompressible flows around complex three-dimensional bodies is developed and demonstrated. The technique is based on numerical integration and a steepest-descent solution procedure and employs a simple lumping scheme to improve the accuracy while providing significantly lower computation times than conventional methods. Results for sample problems involving a helicopter fuselage and a wing are presented in tables and graphs. T.K.

A87-21528#
THE STABILITY OF THE BOUNDARY LAYER ON AN ELLIPSOID AT ANGLE OF ATTACK
S. G. LEKOUDIS (Georgia Institute of Technology, Atlanta) and T. KINARD (Lockheed-Georgia Co., Marietta) AIAA and ASME, Joint Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 8 p. refs
(AIAA PAPER 86-1045)

The linear stability of the boundary layer on an ellipsoid is investigated using the parallel flow assumption. It is found that, at low angles of attack, the stability has the characteristics of both two-dimensional and crossflow instability, in a manner similar to the stability characteristics of midchord regions of swept wings. Moreover the thickening of the boundary layer close to the lee-side of the ellipsoid promotes instability. This thickening is offered as an explanation for the asymmetry of the transition patterns observed on ellipsoids. Author

A87-21530#
VISUALIZATION OF THREE-DIMENSIONAL FORCED UNSTEADY SEPARATED FLOW
M. ROBINSON, H. HELIN (Colorado, University, Boulder), F. GILLIAM, J. RUSSELL, and J. WALKER (U.S. Air Force Academy, Colorado Springs, CO) AIAA and ASME, Joint Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 11 p. USAF-sponsored research. refs
(AIAA PAPER 86-1066)

Three-dimensional unsteady flow separation was visualized for a semi-infinite span wing pitched upward at a constant rate from 0 to 60 deg angles of attack. Initially, many of the same complex flow perturbations, including the formation of leading and trailing edge vortices observed from two-dimensional flow separation were evident. Using the semi-infinite wing, the flow field was further complicated by a wing tip vortex that developed orthogonal to the separation induced leading and trailing edge vortices. The tip flow distorted the development of the initially two-dimensional inboard, leading edge vortex. The simple pitching motion history permitted resolution of the development of individual vortices as a function of airfoil motion parameters. Also, vortex-vortex interactions were examined between separation-induced vortices and wingtip vortices. The interactions were characterized for time periods that extended well beyond the actual pitching motions. Author

A87-21542
ASYMPTOTIC SOLUTIONS FOR UNSTEADY FLOW IN CASCADES
ODDVAR O. BENDIKSEN (Princeton University, NJ) Quarterly of Applied Mathematics (ISSN 0033-5770), vol. 44, Oct. 1986, p. 493-509. refs

Asymptotic methods are presented for obtaining approximate solutions to unsteady flows in oscillating cascades. The formulation is in the framework of linearized potential flow, and the problems considered include low-frequency and low-solidity expansions for subsonic and supersonic cascades. For the supersonic cascade, simple formulas are obtained for the unsteady lift and moment, valid to first order in a frequency parameter. It is shown that terms of successive orders can be obtained by solving a sequence of quasi-static problems, with the effective upwash at each step modified by the lower-order solutions. The approach is in the spirit of matched asymptotic expansions, and different expansions based on different limit processes are sought for the subresonant and superresonant regions. For cascades in subsonic axial flow, the acoustic resonance phenomenon leads to a nonuniformity with respect to the interblade phase angle. The location of the singularity can be moved by suitably redefining the limit process, permitting uniformly valid expansion to be obtained separately for the subresonant and superresonant regions. Numerical comparisons with the full unsteady solution indicate that the present approximations are remarkably accurate in the range of reduced frequencies of interest in aeroelastic analyses. Author

A87-22035
MACH NUMBER EFFECTS ON VORTEX SHEDDING OF A SQUARE CYLINDER AND THICK SYMMETRICAL AIRFOIL ARRANGED IN TANDEM
T. NAKAGAWA (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany; Kanazawa Institute of Technology, Nonoichi, Japan) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 407, no. 1833, Oct. 8, 1986, p. 283-297. Research supported by the Minna-James-Heinemann Foundation. refs

An experimental study was carried out to ascertain the Mach number effects on vortex shedding of a square cylinder and thick symmetrical airfoil arranged in tandem at free stream Mach numbers between 0.1526 and 0.9081, and at free stream Reynolds numbers between 70,200 and 418,800. The spacing ratio of the central distance between the square cylinder and the airfoil to the side length of the square cylinder was varied from 1.125 to 5.5. It is found that the regular vortex shedding is not suppressed by the appearance of steady shock waves in the local supersonic flow reigons. With increasing Mach number, the formation region becomes small and asymmetric while the separating shear layers become wavy. These changes lead to an increase in the scale and strength of the vortices and in effect enhance the vortex shedding process. When the Mach number exceeds the critical value, the formation region is almost symmetrical with respect to the wake axis, and shock waves are formed on the upper and lower separating shear layers. K.K.

A87-22338
ELECTRON-BEAM-METHOD VELOCITY MEASUREMENTS IN SUPERSONIC FLOWS [GESCHWINDIGKEITSMESSUNGEN IN UEBERSCHALLSTROEMUNGEN MIT DER ELEKTRONEN-STRAHLTECHNIK]
CARL DANKERT and KARL ALOYS BUETEFISCH (DFVLR, Goettingen, West Germany) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 52, Sept. 1986, p. 133-138. In German. refs

The use of electron-beam/time-of-flight techniques for measuring gas-flow velocities in the 300-2500 m/s range is discussed in a review of recent experiments and applications. The method permits measurements independent of temperature, pressure, and density and is applicable to wind tunnels and expansion flows. Electron-beam pulses are used to excite atoms in the gas flow; the resulting ions are detected downstream by a collector probe; and the flow velocity is determined by the time-of-flight method. Measurements in a hypersonic nozzle, a supersonic free jet, a molecular beam, and in the exhaust plume of a satellite positioning rocket are described and illustrated with drawing and graphs. T.K.

A87-22351#
A NEW CLASS OF CIRCULATION CONTROL AIRFOILS
N. J. WOOD (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0003)

A new analytical definition for circulation control airfoils has been developed which permits arbitrary thickness and camber distributions while maintaining smooth surface second derivatives. This new definition allows flexibility in the definition of the slot location, slot geometry and number of slots and is ideally suited for optimization studies required to produce improved circulation control rotor performance. Simple inviscid/viscous flow analysis has been used to obtain initial performance characteristics for a number of airfoil geometries and a simple one step optimization has been performed as a feasibility demonstration. Author

A87-22354#
CALCULATION OF UNSTEADY WAKE/ROTOR INTERACTION
MICHAEL B. GILES (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. Research supported by Rolls-Royce, Inc. refs
(Contract N00014-81-K-0024)
(AIAA PAPER 87-0006)

This paper presents a numerical analysis of wake/rotor interaction using a time-marching solution of the unsteady, nonlinear Euler equations. The incoming wakes are specified through the unsteady inflow boundary conditions. The lagged periodic boundary condition which arises due to unequal rotor/stator pitches is handled by a new technique which inclines the computational plane in time. Comparison of results for a flat plate cascade with results using a linear analytic theory demonstrate the method's capability to accurately predict unsteady forces, moments and radiated sound. Results for a low-speed turbine are in agreement with earlier work. Author

A87-22355#
TIME DEPENDENT COMPUTATION OF THE EULER EQUATIONS FOR DESIGNING FULLY 3D TURBOMACHINERY BLADE ROWS, INCLUDING THE CASE OF TRANSONIC SHOCK FREE DESIGN
LUCA ZANNETTI (Torino, Politechnico, Turin, Italy) and TESFAYE TAMIRU AYELE (Addis Ababa, University, Ethiopia) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. Research sponsored by Fiat Aviazione S.p.A. refs
(AIAA PAPER 87-0007)

A numerical method to solve three-dimensional inverse problem for blade row is described. The case of compressible, inviscid, rotational flow is considered. The method is based on the finite-difference approximation of the time dependent Euler equations. Numerical results show the capability of the method to deal with transonic distorted flow. Author

A87-22369*# Boeing Co., Seattle, Wash.
TRANAIR - A COMPUTER CODE FOR TRANSONIC ANALYSES OF ARBITRARY CONFIGURATIONS
S. S. SAMANT, J. E. BUSSOLETTI, F. T. JOHNSON, R. H. BURKHART, B. L. EVERSON, R. G. MELVIN, D. P. YOUNG (Boeing Co., Seattle, WA), L. L. ERICKSON, M. D. MADSON (NASA, Ames Research Center, Moffett Field, CA) et al. AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 19 p. Research supported by the Boeing Independent Research and Development Funds. refs
(Contract NAS2-11851; E(11-1)-3070; NSG-1323)
(AIAA PAPER 87-0034)

Attention is given to a new approach to solving full potential equations about arbitrary configurations. Numerical algorithms from such fields as finite elements, preconditioned Krylov subspace methods, discrete Fourier analysis, and integral equations are combined to take advantage of the size and speed of current and emerging supercomputers. On the basis of this appraoch, a robust, efficient and easy to use computer code referred to as TRANAIR has been developed for transonic analysis of complex geometries. K.K.

A87-22370*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGHLIGHTS OF UNSTEADY PRESSURE TESTS ON A 14 PERCENT SUPERCRITICAL AIRFOIL AT HIGH REYNOLDS NUMBER, TRANSONIC CONDITION
ROBERT W. HESS, DAVID A. SEIDEL, WILLIAM B. IGOE, and PIERCE L. LAWING (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 18 p. refs
(AIAA PAPER 87-0035)

Steady and unsteady pressures were measured on a two-dimensional supercritical airfoil in the Langley 0.3-m Transonic Cryogenic Tunnel at Reynolds numbers (6-35) x 10 to the 6th. The airfoil was oscillated in pitch at amplitudes from + or - .25 degrees to + or - 1.0 degrees at frequencies from 5 Hz to 60

Hz. The special requirements of testing an unsteady pressure model in a pressurized cryogenic tunnel are discussed. Selected steady measured data are presented and are compared with GRUMFOIL calculations at Reynolds number 6 x 10 to the 6th and 30 x 10 to the 6th. Experimental unsteady results at the same Reynolds numbers are examined for Reynolds-number effects. Measured unsteady results at two mean angles of attack at Reynolds number of 30 x 10 to the 6th are also examined. Author

A87-22372*# Massachusetts Inst. of Tech., Cambridge.
LEADING-EDGE VORTEX SOLUTIONS WITH LARGE TOTAL PRESSURE LOSSES
EARLL M. MURMAN, KENNETH G. POWELL, AGA M. GOODSELL, and MARTEN T. LANDAHL (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 16 p. Research supported by the Flygtekniska Forsoksanstalten of Sweden. refs
(Contract NAG1-358; N00014-86-K-0288)
(AIAA PAPER 87-0039)

Computations are presented for a Lambda = 75 deg delta wing in a supersonic freestream under two conditions which lead to leading-edge vortices. For one condition, analysis of the computed vortical flow reveals a closed streamline in the core. From varying computational parameters, it appears that this is due to truncation error of the convective derivatives. For the other condition, comparisons are made with wind-tunnel data, and good agreement is noted for pitot pressure distributions, flow angles on the symmetry plane, and the position of an embedded shock. Many of the aerodynamic parameters are shown to be insensitive to grid spacing. Author

A87-22373#
IMPROVEMENTS TO AN EULER AERODYNAMIC METHOD FOR TRANSONIC FLOW ANALYSIS
PRADEEP RAJ and JAMES E. BRENNAN (Lockheed-California Co., Burbank) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract F33615-84-C-3005)
(AIAA PAPER 87-0040)

Modifications to a Three-dimensional Euler Aerodynamic Method (TEAM) and their effect on the accuracy of transonic flow simulations are discussed. TEAMs solution algorithm is based on finite-volume spatial discretization and multistage Runge-Kutta time stepping. Formulation of numerical dissipation terms near the boundaries and a precise treatment of the surface boundary condition are specifically addressed. The modified code includes an option to select either the adaptive dissipation using blended second and fourth differences or flux-limited dissipation. Results for two wings, ONERA M-6 and Wing C, and an arrow wing-body configuration are presented to illustrate the effect of these modifications. Surface pressure distributions computed using the TEAM code are correlated with experimental data. For Wing C, the TEAM solutions are also compared with the predictions of the TWING code which is based on the full-potential equations. Author

A87-22374*# Old Dominion Univ., Norfolk, Va.
FINITE-VOLUME EULER AND NAVIER-STOKES SOLVERS FOR THREE-DIMENSIONAL AND CONICAL VORTEX FLOWS OVER DELTA WINGS
OSAMA A. KANDIL, ANDREW H. CHUANG, and JAMES M. SHIFFLETTE (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 19 p. refs
(Contract NAG1-648)
(AIAA PAPER 87-0041)

A unified central-difference finite-volume Euler and Navier-Stokes solver with four-stage Runge-Kutta time stepping is presented. The computer code developed for this purpose is capable of solving the standard set and nonstandard sets (zero-total-pressure loss) of Euler equations and the thin-layer and full Navier-Stokes equations. Applications are presented for conical supersonic flows with weak shocks using the standard and nonstandard sets of Euler equations, and the thin-layer and full Navier-Stokes equations for sharp and round-edged delta wings. Applications are also presented for three-dimensional transonic and subsonic flows using the standard set of Euler equations for sharp-edged delta wings. The computational results of the different sets of equations are compared with each other and with the experimental results and conclusions on the validity of these sets to these applications, are presented. Author

A87-22382*# Tennessee Univ., Knoxville.
THREE-DIMENSIONAL NEARFIELD CHARACTERIZATION OF A VSTOL JET IN TURBULENT CROSSFLOW
A. J. BAKER (Tennessee, University, Knoxville), P. K. SNYDER (NASA, Ames Research Center, Moffett Field, CA), and J. A. ORZECHOWSKI (Computational Mechanics Corp., Knoxville, TN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. NASA-supported research. refs
(Contract N62269-84-C-0264)
(AIAA PAPER 87-0051)

This paper documents the measurement and prediction of the near-field evolution of the steady, subsonic, turbulent three-dimensional external aerodynamic flow-field associated with a high speed jet issued from an orifice perpendicular to an imposed crossflow velocity field. A parabolic Navier-Stokes CFD solver is employed, utilizing a Kappa-epsilon closure system with algebraic Reynolds stress equation, in concert with suitably defined porous far-field boundary conditions and a virtual source initial condition procedure. The CFD results correlate well with NASA generated near-field LDA experimental data on mean velocity and rms fluctuation velocity (interpolated to turbulent kinetic energy) distributions. The numerical results in the farther field predict the vortex roll-up and jet deflection/entrainment characterization verified by pitot-static mean velocity experimental data. Detailed results are presented for a circular jet for velocity ratios ranging 4 to 8. Author

A87-22385#
INTERACTION OF JET IN HYPERSONIC CROSS STREAM
J. S. SHANG, D. L. MCMASTER, N. SCAGGS, and M. BUCK (USAF, Wright-Patterson Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0055)

A jet stream issuing normally from both sharp and blunt nose ogive-cylinder configurations into a hypersonic flow was investigated by a side-by-side experimental and numerical simulation. At a hypersonic Mach number of twelve, strong interaction between jet induced and bow shock wave systems, the jet plume trajectory and the separated flow surface shear pattern were highlighted for basic understanding. After the numerical solution was verified with the experimental data, the flow field topology was reconstructed. Several unique features of this inviscid-viscous interaction phenomenon of shockwave formation, vortical flow structure and jet plume were delineated. Author

A87-22406#
LAMINARIZATION OF TRANSPORT AIRCRAFT WINGS - A GERMAN VIEW
H. KOERNER, K. H. HORSTMANN, H. KOESTER, A. QUAST, and G. REDEKER (DFVLR, Institut fuer Entwurfsaerodynamik, West Germany) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0985)

Natural laminar flow is obtainable through proper contouring of airfoil profiles used in sailplanes, propeller and helicopter rotor blades, and commuter aircraft wings. Aerodynamic surfaces exposed to higher Reynolds numbers, however (in the 10 to 30 million range) radicalize the problems of transition prediction and of wind tunnel data qualification through comparisons with data obtained in flight tests. Attention is presently given to representative examples of the state-of-the-art in natural laminar flow airfoil design developed by the DFVLR for various flight regimes, as well as to

prospective gains in overall subsonic transport aircraft aerodynamic efficiency that flight tests have indicated to be obtainable by these means. O.C.

A87-22414*# Dayton Univ., Ohio.
NAVIER STOKES SOLUTION OF THE FLOWFIELD OVER ICE ACCRETION SHAPES
J. N. SCOTT, W. L. HANKEY, F. J. GIESSLER, and T. P. GIELDA (Dayton, University, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(Contract NAG3-665)
(AIAA PAPER 87-0099)

The numerical simulation of flow about ice accretion shapes has been accomplished by solving the Navier-Stokes equations using MacCormack's explicit finite difference scheme. The computations were performed on a CRAY-XMP computer. The influence of turbulence is taken into account by means of an algebraic eddy-viscosity model. In order to optimize the grid spacing and to achieve near orthogonality at the surface of the complex ice shapes, a hyperbolic grid generation scheme is utilized. Particular attention is given to the heat transfer process for which good agreement between the numerical and experimental results is achieved. In addition, liquid water droplet trajectories are coupled within the flowfield along with the resulting collection efficiencies using a parabolized Navier-Stokes formulation. Author

A87-22415*# Akron Univ., Ohio.
NUMERICAL ANALYSIS OF A NACA0012 AIRFOIL WITH LEADING EDGE ICE ACCRETIONS
MARK G. POTAPCZUK (Akron, University, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG3-416)
(AIAA PAPER 87-0101)

Analysis of a NACA0012 airfoil with leading edge ice has been performed using a Navier-Stokes code coupled with a grid generation code. The computed results were compared to experimental information obtained for an airfoil with a well defined artificial ice shape. The computations were performed at angles of attack ranging from zero to ten degrees. This range is sufficient to show the development of the separation bubble aft of the ice shape on both the upper and lower surfaces. Velocity profile plots in the separation bubble are examined in order to determine if recirculation patterns are predicted properly and if separation and reattachment points are found within the resolution of the experimental information. Also, the massive separation near the point of stall is examined in order to more accurately evaluate the lift coefficient curve in that region. Lift, drag, and moment coefficients are computed and compared to experiment. Author

A87-22418*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL METHODS FOR UNSTEADY TRANSONIC FLOWS
JOHN W. EDWARDS and JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 30 p. refs
(AIAA PAPER 87-0107)

Computational methods for unsteady transonic flows are surveyed with emphasis upon applications to aeroelastic analysis and flutter prediction. Computational difficulty is discussed with respect to type of unsteady flow; attached, mixed (attached/separated) and separated. Significant early computations of shock motions, aileron buzz and periodic oscillations are discussed. The maturation of computational methods towards the capability of treating complete vehicles with reasonable computational resources is noted and a survey of recent comparisons with experimental results is compiled. The importance of mixed attached and separated flow modeling for aeroelastic analysis is discussed and recent calculations of periodic aerodynamic oscillations for an 18 percent thick circular arc airfoil are given. Author

A87-22419#
SOLUTION OF UNSTEADY ROTATIONAL FLOW OVER SUPERCRITICAL WINGS
S. Y. RUO (Lockheed-Georgia Co., Marietta) and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0108)

Steady and unsteady transonic flow over thick supercritical wings is analyzed through the numerical solution of the three-dimensional Euler equations. These equations are solved in a body-fitted coordinate system, through a solution procedure that is first order accurate in time, and second order accurate in space. Wing surface motions are modeled either through a transpiration boundary condition approach, or through the motion of the body-fitted grid. A number of steady and unsteady transonic flow calculations are presented and compared with experimental data. The relative merits of the transpiration and the exact boundary condition approaches are assessed. Author

A87-22420*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EFFICIENT ALGORITHM FOR SOLUTION OF THE UNSTEADY TRANSONIC SMALL-DISTURBANCE EQUATION
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0109)

A time accurate approximation factorization (AF) algorithm is formulated for solution of the three-dimensional unsteady transonic small-disturbance equation. The AF algorithm consists of a time linearization procedure coupled with a Newton iteration technique. Superior stability characteristics of the new algorithm are demonstrated through applications to steady and oscillatory flows at subsonic and supersonic freestream conditions for an F-5 fighter wing. For steady flow calculations, the size of the time step is cycled to achieve rapid convergence. For unsteady flow calculations, the AF algorithm is sufficiently robust to allow the step size to be selected based on accuracy rather than on stability considerations. Therefore, accurate solutions are obtained in only several hundred time steps yielding a significant computational cost savings when compared to alternative methods. Author

A87-22424*# Old Dominion Univ., Norfolk, Va.
COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF CAVITY FLOWFIELDS
O. BAYSAL (Old Dominion University, Norfolk, VA) and R. L. STALLINGS, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG1-559)
(AIAA PAPER 87-0114)

This paper presents a computational and experimental investigation of supersonic flow past a cavity in a flat plate. The source of the particular interest in this problem is the ongoing study of the aerodynamic interference effects between a separating store and its bay in the parent body. An upwind relaxation scheme, utilizing flux vector splitting and line-Gauss-Seidel iterations, is used to solve Reynolds-averaged Navier-Stokes equations. Spatial discretizations of this two-dimensional analysis are based on implicit and finite-volume methods. Turbulence is modeled and shocks are captured. The flowfield of the symmetry plane at the half-width is computationally visualized and all flow properties are computed. Experimental tests are conducted in the Langley Unitary Plan Wind Tunnel to measure wall pressures and to capture schlieren photographs. Qualitative as well as quantitative data of computations and experiments agree very well. These two vehicles of investigation are merged to show open, closed and transitional cavity flow behaviors. Author

A87-22425*# PEDA Corp., Palo Alto, Calif.
NUMERICAL SIMULATION OF COMPRESSIBLE FLOW AROUND COMPLEX TWO-DIMENSIONAL CAVITIES
ETHIRAJ VENKATAPATHY, C. K. LOMBARD, and N. NAGARAJ (PEDA Corp., Palo Alto, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(Contract NAS2-11920)
(AIAA PAPER 87-0116)

Compressible viscous flow around two-dimensional cavities, that model the midplane flow in and around an airborne telescope cavity, are obtained through numerical simulation. Numerical solutions using the patched grid CSCM scheme for compressible, unsteady flow are presented for the cavities, with and without blowing. The time evolving solutions show interesting flow features. Relevant results for a limited number of problems presented here show the unsteady nature of the flow and its dependence on various parameters such as Reynolds number, the wall conditions, etc. The voluminous data of time evolving flow field solutions are analyzed through movies of the velocity vectors, and contours of other flow variables. Author

A87-22429#
EXPERIMENTAL INVESTIGATION OF SHOCK INDUCED BUFFETING TROUGH HOLOGRAPHIC INTERFEROMETRY
D. BASLER (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, West Germany) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0123)

The mechanism leading to and associated with shock-induced buffeting is studied experimentally in a transonic test-section integrated into a Ludweig-tube facility. A holographic high-speed real-time interferometer was developed to observe and analyze the entire flow field surrounding the airfoil. The interferometer's main components are an argon-ion laser with an acousto-optic output coupler, a variable beam splitter, two parabolic mirrors, a holographic plate, and a high-speed camera. For the characteristic flow condition presently considered, a temporal as well as a local correlation between the shock oscillation and the oscillation of the boundary layer is found. K.K.

A87-22439#
AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A CRUCIFORM MISSILE IN SUBSONIC FLOW
M. S. MILLER (Auburn University, AL) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0143)

Experimental results obtained from an investigation of aerodynamic characteristics of a cruciform missile in subsonic flow are presented. The data, obtained from wind tunnel tests of an instrumented pressure model of a cruciform missile, are used to quantitatively determine fin-fin interference effects on a cruciform missile when it is arbitrarily rolled and pitched. Results show that fin-fin interference effects are present at all roll angles, and are generally most significant on the inboard sections of each fin. Additionally, the suitability of an analytical technique based on planar lifting surface theory to accurately model the flow field is determined by comparison with experimental fin pressure distributions and with sectional normal force coefficients. Author

A87-22446#
DEVELOPMENT OF COMPRESSIBLE FLOW SIMILARITY CONCEPTS FOR CIRCULATION CONTROL AIRFOILS
ERNEST O. ROGERS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(AIAA PAPER 87-0153)

Compressible flow similarity relationships are empirically derived from performance data of four geometrically related circulation control airfoils. The similarity factors, relating geometry and Mach number, differ from those of conventional airfoils and provide insight into the basic phenomena of boundary-layer control. The performance data for all four airfoils collapse onto a single curve revealing that both maximum lift increment and augmentation ratio vary with Mach number, first by increasing linearity with speed and then by decreasing linearly. The effect of geometry is to shift the Mach number where peak performance occurs. Limits of airfoil incremental lift (stall) correspond to attaining limiting flow Mach numbers in the trailing edge region. The origin of the extraordinary influence of free-stream velocity on augmentation ratio remains unidentified; Reynolds number cannot be substantiated as a primary factor. Author

A87-22447*# Analytical Methods, Inc., Redmond, Wash.
IMPROVED ALGORITHMS FOR CIRCULATION-CONTROL AIRFOILS IN TRANSONIC FLOW
FRANK A. DVORAK, DANIEL J. STRASH (Analytical Methods, Inc., Redmond, WA), BRIAN J. YORK, and SANFORD M. DASH (Science Applications International Corp., Princeton, NJ) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NAS2-12135)
(AIAA PAPER 87-0154)

A zonal model for aerodynamic analysis of two-dimensional transonic circulation control airfoils has been developed. The present approach combines a transonic full potential method for the global flow field and an integral boundary layer method for regions of the airfoil excluding the wall jet with a parabolized Navier-Stokes code for resolving the wall jet region beyond the slot. Existing methods suffer from two deficiencies: the insensitivity of the calculation to small changes in the Coanda surface geometry; and the inability to predict the shock structure of the underexpanded supersonic wall jets. The present wall jet procedure involves a pressure-split approach in the streamwise sense to enable noniterative solution of the coupled continuity and normal momentum equations for increased surface sensitivity and allows for expansion of applications to sonic slot exit conditions. Encouraging results are obtained in comparison with experimental data for two circulation airfoils with subsonic wall jets. Author

A87-22448#
EXPERIMENTAL INVESTIGATIONS OF THE CIRCULAR WALL JET ON A CIRCULATION CONTROL AIRFOIL
CHARLES J. NOVAK, KENNETH C. CORNELIUS, and RONALDA K. ROADS (Lockheed-Georgia Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. DARPA-supported research. refs
(Contract N00167-86-C-0006)
(AIAA PAPER 87-0155)

The circular wall jet on a circulation control airfoil model's flow field was studied using a two-dimensional laser velocimeter. In addition to the velocity data, surface pressure data were obtained, permitting the study of the performance aspects of the model airfoil. Wind tunnel wall-surface pressure data were also acquired so that methods to determine the equivalent free air angle of attack could be employed for use in experimental/numerical comparisons. I.S.

A87-22449*# McDonnell-Douglas Corp., St. Louis, Mo.
BOUNDARY-LAYER AND WAKE MEASUREMENTS ON A SWEPT, CIRCULATION-CONTROL WING
FRANK W. SPAID (McDonnell Douglas Corp., Saint Louis, MO) and EARL R. KEENER (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. Research supported by the McDonnell Douglas Independent Research and Development Program and NASA. refs
(AIAA PAPER 87-0156)

Wind-tunnel measurements of boundary-layer and wake velocity profiles and surface static-pressure distributions are presented for a swept, circulation-control wing. The model is an aspect-ratio-four semispan wing mounted on the tunnel side wall at a sweep angle of 45 deg. A full-span, tangential, rearward-blowing, circulation-control slot is located ahead of the trailing edge on the upper surface. Flow surveys were obtained at mid-semispan at

freestream Mach numbers of 0.425 and 0.70. Boundary-layer profiles measured on the forward portions of the wing are approximately streamwise and two-dimensional. The flow in the vicinity of the jet exit and in the near wake is highly three-dimensional. The jet flow near the slot on the Coanda surface is directed normal to the slot. Near-wake surveys show large outboard flows at the center of the wake. At Mach 0.425 and a 5-deg angle of attack, a range of jet blowing rates was found for which an abrupt transition from incipient separation to attached flow occurs in the boundary layer upstream of the slot. The variation in the lower-surface separation location with blowing rate was determined from boundary-layer measurements at Mach 0.425. Author

A87-22450#
THE CONTROL OF VORTICAL LIFT ON DELTA WINGS BY TANGENTIAL LEADING EDGE BLOWING
N. J. WOOD and L. ROBERTS (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0158)

An experiment has been performed to examine the feasibility of vortex control by tangential mass injection at the leading edge of a 60-deg delta wing. The initial results indicate that direct control of the primary separation allows significant control of the vortex flow up to angles of attack of 60 deg. At lower angles of attack, the vortical flow may be removed entirely from the surface of the wing, recovering the fully attached flow case. The effects of the mass injection have been shown to be decoupled from the geometric angle of attack allowing the possibility for controlling lift without changing attitude. Author

A87-22472*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A COMPUTATIONAL ANALYSIS OF FLOW SEPARATION OVER FIVE DIFFERENT AIRFOIL GEOMETRIES AT HIGH ANGLES-OF-ATTACK
CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0188)

The flux splitting method of Van Leer (1982) and an implicit, upwind-biased, finite-volume scheme of Rumsey (1985) for solving the two-dimensional Reynolds-averaged Navier-Stokes equations were applied to analyze five airfoil geometries (the NACA 0012, 12-percent Joukowski, NACA 4412, NACA 65-015, and LS1-0417 sections), at high angles of attack. The effect of grid density and grid extent on the Strouhal number of the unsteady flow was computed, as well as the effect of variations in Mach number, Reynolds number, and angle of attack. It was found, that past an angle of attack of 20 deg, Strouhal numbers were independent of angle of attack (at a constant value of 0.115), agreeing well with the experimental findings of Tyler (1931). I.S.

A87-22474*# Massachusetts Inst. of Tech., Cambridge.
ENERGETICS OF OSCILLATING LIFTING SURFACES USING INTEGRAL CONSERVATION LAWS
ALI R. AHMADI (BBN Laboratories, Inc., Cambridge, MA) and SHEILA E. WIDNALL (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 23 p.
(Contract NGR-22-009-818)
(AIAA PAPER 87-0193)

The energetics of oscillating flexible lifting surfaces in two and three dimensions is calculated by the use of integral conservation laws in inviscid incompressible flow for general and harmonic transverse oscillations. Total thrust is calculated from the momentum theorem and energy loss rate due to vortex shedding in the wake from the principle of conservation of mechanical energy. Total power required to maintain the oscillations and hydrodynamic efficiency are also determined. In two dimensions, the results are obtained in closed form. In three dimensions, the distribution of vorticity on the lifting surface is also required as input to the calculations. Thus, unsteady lifting-surface theory must be used as well. The analysis is applicable to oscillating lifting surfaces of arbitrary planform, aspect ratio, and reduced frequency and does not require calculation of the leading-edge thrust. Author

A87-22483*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VORTICAL FLOW AERODYNAMICS - PHYSICAL ASPECTS AND NUMERICAL SIMULATION
RICHARD W. NEWSOME (NASA, Langley Research Center; USAF, Flight Dynamics Laboratory, Hampton, VA) and OSAMA A. KANDIL (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 40 p. refs
(AIAA PAPER 87-0205)

Progress in the numerical simulation of vortical flow due to three-dimensional flow separation about flight vehicles at high angles of attack and quasi-steady flight conditions is surveyed. Primary emphasis is placed on Euler and Reynolds-averaged Navier-Stokes methods where the vortices are 'captured' as a solution to the governing equations. A discussion of the relevant flow physics provides a perspective from which to assess numerical solutions. Current numerical prediction capabilities and their evolutionary development are surveyed. Future trends and challenges are identified and discussed. Author

A87-22484*# Kansas Univ., Lawrence.
INCOMPRESSIBLE NAVIER-STOKES SOLUTIONS FOR A SHARP-EDGED DOUBLE-DELTA WING
CHUNG-HAO HSU (Kansas, University, Lawrence), PETER-MICHAEL HARTWICH (Vigyan Research Associates, Inc., Hampton, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG1-455; NAS1-17919)
(AIAA PAPER 87-0206)

An implicit finite-difference scheme is used to compute the incompressible laminar vortical flow around a double-delta wing with an aspect ratio of 2.06. By adding a time derivative of the pressure to the continuity equation, the unsteady incompressible Navier-Stokes equations can be integrated like a conventional parabolic time-dependent system of equations. The flux-difference split scheme combines approximate factorization in crossflow planes with a symmetric planar Gauss-Seidel relaxation in the remaining spatial direction. The trajectory of the vortical core is well predicted in comparison with experimental data. Author

A87-22485*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NAVIER-STOKES COMPUTATIONS OF VORTICAL FLOWS OVER LOW ASPECT RATIO WINGS
J. L. THOMAS, S. L. TAYLOR (NASA, Langley Research Center, Hampton, VA), and W. K. ANDERSON AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0207)

An upwind-biased finite-volume algorithm is applied to the low-speed flow over a low aspect ratio delta wing from zero to forty degrees angle of attack. The differencing is second-order accurate spatially, and a multigrid algorithm is used to promote convergence to the steady state. The results compare well with the detailed experiments of Hummel (1983) and others for a Re(L) of 0.95 x 10 to the 6th. The predicted maximum lift coefficient of 1.10 at thirty-five degrees angle of attack agrees closely with the measured maximum lift of 1.06 at thirty-three degrees. At forty degrees angle of attack, a bubble type of vortex breakdown is evident in the computations, extending from 0.6 of the root chord to just downstream of the trailing edge. Author

A87-22486#
AN EXPERIMENTAL INVESTIGATION OF THE PERPENDICULAR VORTEX-AIRFOIL INTERACTION AT TRANSONIC SPEEDS
DONALD R. WILSON, IRAJ M. KALKHORAN, and DONALD D. SEATH (Texas, University, Arlington) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract DAAG29-84-K-0131)
(AIAA PAPER 87-0208)

Transonic vortex-airfoil interaction tests at Mach numbers ranging from 0.68-0.86 and airfoil Reynolds numbers of 3.8-5.5 million were conducted in the UTA high-Reynolds number, transonic Ludwieg tube wind tunnel. The scheme involves positioning a lifting wing (vortex generator) upstream of a NACA 0012 airfoil so that the trailing vortex interacts with the downstream airfoil. Tests were performed at several vortex strengths as well as several vortex core heights above the downstream airfoil. The results obtained from these experiments indicate a substantial change in the pressure distribution of the airfoil, a spanwise drift of the vortex core as it passes over the trailing airfoil similar to the results observed previously in low-speed wind-tunnel tests conducted at UTA, and a high degree of unsteadiness in the vicinity of the vortex core. Author

A87-22487#
IFM APPLICATIONS TO THEORETICAL TRAJECTORY PREDICTIONS
A. CENKO, K. CRAIG (Hofstra University, Hempstead, NY), W. TSENG (U.S. Navy, Naval Air Development Center, Warminster, PA), and J. TUSTANIWSKYJ (Unisys, San Diego, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0210)

The Influence Function Method (IFM) is an innovative technique for predicting store loads within an aircraft flowfield. The method was initially developed to utilize data obtained for one store in its parent aircraft flowfield to predict the forces and moments on another store in the same flowfield. It has since been shown to be capable of accurately predicting external aircraft flowfields, as well as using experimental or theoretical flowfield data to predict store grid loads, including carriage. Recently, trajectory test data for the BQM-126A drone separating from the A6-E aircraft were acquired. These data are used to evaluate the ability of the IFM method to theoretically predict store trajectories from fighter aircraft. Author

A87-22491#
NORMAL FORCE CHARACTERISTICS AT SUPERSONIC SPEEDS OF SHARP EDGED DELTA WINGS
ERIK S. LARSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. Research supported by the Armed Forces of Sweden. refs
(AIAA PAPER 87-0214)

For the restricted interval of reduced aspect ratios for sharp-edged delta wings at supersonic speeds, bounded by the lowest Mach number for establishing conical flow around the wing and, as an upper bound, the Mach number for sonic leading-edge flow, an engineering method for estimating the normal-force characteristics is under development, and the first result is presented. The method is compiled by utilizing experimental results from several sources and basic flow characteristics, as: the vacuum limit, the pressure loss factor and the face drag of disks. Experimental lift-curve slope data show that the wing thickness-to-chord ratio can not be discarded and, therefore, the present result is prepared for wings with a fixed profile apex half-angle in the flow direction. The analytic expressions for various partial contributions to the normal-force of the delta wing are characterized by formal simplicity and represent quite satisfactorily experimental data. To improve the engineering method an accurate knowledge of the partitioning of the attached flow lift-curve slope between upper and lower surface of the delta wing is needed from experiments and/or higher-order flow-theories. Author

A87-22503#
A NUMERICAL STUDY OF THE WEIS-FOGH MECHANISM
M. H. SOHN (Korean Air Force Acadamy, Seoul, Republic of Korea) and J. C. WU (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract AF-AFOSR-82-0108; AF-AFOSR-86-0121)
(AIAA PAPER 87-0238)

The aerodynamic mechanism associated with the Weis-Fogh wings is investigated through a numerical solution of the Navier-Stokes equations. Two types of wing motion, the fling phase only and the fling phase followed by the separation phase, are treated at flow Reynolds numbers 32 and 13,000. The development of the flow and the aerodynamic characteristics of the Weis-Fogh wings are analyzed through computed streamlines, equi-vorticity contours and aerodynamic load histories. The results confirm several zoological and experimental observations of previous investigators and provide additional qualitative and quantitative informations about the Weis-Fogh mechanism. Author

A87-22505*# Notre Dame Univ., Ind.
A STUDY OF THE LAMINAR SEPARATION BUBBLE ON AN AIRFOIL AT LOW REYNOLDS NUMBERS USING FLOW VISUALIZATION TECHNIQUES
GORDON S. SCHMIDT and THOMAS J. MUELLER (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. Research supported by the University of Notre Dame. refs
(Contract NSG-1419)
(AIAA PAPER 87-0242)

The use of flow visualization to study separation bubbles is evaluated. The wind tunnel, two NACA 66(3)-018 airfoil models, and kerosene vapor, titanium tetrachloride, and surface flow visualizations techniques are described. The application of the three visualization techniques to the two airfoil models reveals that the smoke and vapor techniques provide data on the location of laminar separation and the onset of transition, and the surface method produces information about the location of turbulent boundary layer separation. The data obtained with the three flow visualization techniques are compared to pressure distribution data and good correlation is detected. It is noted that flow visualization is an effective technique for examining separation bubbles. I.F.

A87-22517#
RAIN EFFECTS AT LOW REYNOLDS NUMBER
J. F. MARCHMAN, III, EDWARD A. ROBERTSON, and HOWARD T. EMSLEY (Virginia Polytechnic Institute and State University, Blacksburg, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0258)

Wind tunnel tests were conducted to determine the influence of rain on the aerodynamic performance of the Wortmann FX63-137 wing at Reynolds numbers from 100,000 through 300,000. Models with aspect ratios of 6 and 4 were tested with normal as well as waxed and soaped surfaces to evaluate wettability effects. Test results showed an improvement of performance at the lowest Reynolds number but general deterioration at higher speeds. The primary effect noted was a decrease in lift at higher angles of attack. A favorable result was the elimination of stall hysteresis which characterizes the Wortmann's normal performance at low Reynolds numbers. At lower Reynolds numbers, rain appeared to lower drag, while at higher speeds drag generally increased. Author

A87-22518*# Massachusetts Inst. of Tech., Cambridge.
COMPARATIVE LOW REYNOLDS NUMBER TESTS OF NACA 64-210, NACA 0012, AND WORTMANN FX67-K170 AIRFOILS IN HEAVY RAIN
R. JOHN HANSMAN, JR. and ANTHONY P. CRAIG (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG1-568)
(AIAA PAPER 87-0259)

The effect of simulated rain at 1000 mm/h on the aerodynamic performance of NACA 64-210, NACA 0012, and Wortmann FX67-K170 airfoils is investigated experimentally at Reynolds number 310,000, freestream velocity 70 mph, and angle of attack -10 to +20 deg in the 1 x 1-ft section of the MIT low-turbulence wind tunnel. The results are presented graphically and characterized in detail. Rain is found to produce lift degradation of 5-25 percent, an effect attributed to development of a premature transition at the leading edge followed (after 1-10 s) by alteration of the profile by surface water runback. T.K.

A87-22519*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND TUNNEL TEST RESULTS OF HEAVY RAIN EFFECTS ON AIRFOIL PERFORMANCE
G. M. BEZOS, R. E. DUNHAM, JR., G. L. GENTRY, JR. (NASA, Langley Research Center, Hampton, VA), and W. EDWARD MELSON, JR. (NASA, Wallops Flight Center, Wallops Island, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0260)

The effects of simulated heavy rain on the aerodynamic characteristics of a NACA 64-210 airfoil section equipped with high-lift devices were investigated in the NASA Langley 14- by 22-Foot Subsonic Tunnel. The experiment was part of an on-going NASA program to determine the effect of heavy rain on airplane performance, and was directed at providing insight into scaling laws for subscale model testing of rain effects. The model used in the investigation had a chord of 2.5 feet, a span of 8.0 feet, and was mounted on the tunnel centerline between two large endplates. A water spray distribution system was located 10 chord lengths upstream of the model. The sensitivity of test results to partial-span coverage of the model in the simulated rain environment as compared to full-span coverage was also investigated. The lift and drag data obtained for the high-lift configuration show excellent repeatability of results compared to the previous data. Results obtained for various spray concentrations and tunnel speeds showed significant losses in maximum lift capability, a decrease in the angle of attack for maximum lift, and an increase in drag as the stimulated rain rate was increased. The test results also indicated that the data were not strongly affected by surface tension effects for the high-lift configuration. Author

A87-22522*# PRC Kentron, Inc., Hampton, Va.
ENGINEERING ANALYSIS OF SLENDER-BODY AERODYNAMICS USING SYCHEV SIMILARITY PARAMETERS
MICHAEL J. HEMSCH (PRC Kentron, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAS1-18000)
(AIAA PAPER 87-0267)

The similarity parameters deduced by Sychev for inviscid hypersonic flow over slender bodies are reviewed and used to correlate flowfield, surface-pressure, normal-force and center-of-pressure data for supersonic flow over thin slender wings and smooth slender bodies at low-to-high angles of attack. Although Sychev expected similarity to hold only for hypersonic freestream and cross flows, it is demonstrated empirically that similarity holds for any value of cross-flow Mach number if the axial flow component is supersonic. It is also shown for thin wings that similarity holds for much larger values of aspect ratio than Sychev supposed. A one-term power-law expression is found to fit all of the normal-force correlations which suggests that it may be possible to develop a simple semi-empirical method for estimating the aerodynamic characteristics of arbitrary slender airframes. Author

A87-22531*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL ANALYSIS OF HYPERSONIC AIRBREATHING AIRCRAFT FLOW FIELDS
DOUGLAS L. DWOYER and AJAY KUMAR (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 18 p. refs
(AIAA PAPER 87-0279)

The general problem of calculating the flow fields associated with hypersonic airbreathing aircrafts is presented. Unique aspects of hypersonic airplane aerodynamics are introduced and their demands on CFD are outlined. Example calculations associated with inlet/forebody integration and hypersonic nozzle design are presented to illustrate the nature of the problems considered. Author

A87-22542*# Old Dominion Univ., Norfolk, Va.
EFFECT OF ASPECT RATIO ON SIDEWALL BOUNDARY-LAYER INFLUENCE IN TWO-DIMENSIONAL AIRFOIL TESTING
A. V. MURTHY (Old Dominion University Research Foundation, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. Previously announced in STAR as N86-31534. refs
(Contract NAG1-334)
(AIAA PAPER 87-0295)

The effect of sidewall boundary layers in airfoil testing in two-dimensional wind tunnels is investigated. The non-linear crossflow velocity variation induced because of the changes in the sidewall boundary-layer thickness is represented by the flow between a wavy wall and straight wall. Using this flow model, a correction for the sidewall boundary-layer effects is derived in terms of the undisturbed sidewall boundary-layer properties, the test Mach number and the airfoil aspect ratio. Application of the proposed correction to available experimental data showed good correlation for the shock location and pressure. Author

A87-22564#
AN INVESTIGATION OF LEADING-EDGE VORTICES ON DELTA WINGS WITH JET BLOWING
J. M. WU, A. D. VAKILI (Tennessee, University, Tullahoma), and Z. SHI AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0330)

The leading-edge vortex structure and its breakdown have been studied in the water tunnel using both conventional dye and laser-induced-fluorescence/dye flow-visualization techniques. It was observed that, on a delta wing with 55-deg sweep angle, the classical large vortex initiated at the apex and merged together with a series of small vortices periodically shed from the leading edge. The vortex burst that was frequently observed was of the spiral type: the bubble type was also observed but only for short time periods and switched rapidly to the spiral type. As the Reynolds number, range increased from 10,000 to 50,000, the vortex breakdown position (VBP) moved toward the apex. With a single forward and a rearward blowing jet it was found that both the axial velocity and its gradient strongly affect the VBP. The VBP was markedly delayed by one or both of the following techniques: a single jet blowing along the direction tangential to the vortex core and spanwise blowing in a steady manner. Spanwise blowing, with periodicity at very low frequencies was found very effective for low angles of attack up to 25 deg. It was also observed that the flow field of the wing apex had a significant influence on the vortex breakdown. A pair of 'guiding' plates, symmetrically positioned at the apex also delayed the vortex breakdown. Author

A87-22566#
LEADING EDGE VORTEX DYNAMICS ON A DELTA WING UNDERGOING A WING ROCK MOTION
YOUNG-WHOON JUN and ROBERT C. NELSON (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0332)

Experimental data is presented which shows the dynamic behavior of the leading edge vortices on an 80 degree swept delta wing undergoing a wing rock motion. Vortex trajectory data was determined from smoke flow visualization experiments. The photographic data was analyzed to determine vortex position and breakdown information. Significant differences were observed between the static and dynamic vortex core positions and the breakdown locations. The data shows the convective lag in the flow field development on an oscillating wing. Author

A87-22575#
BLOCK-STRUCTURED SOLUTION OF EULER EQUATIONS FOR TRANSONIC FLOWS
AKIN ECER, JOHN T. SPYROPOULOS, and OKTAR ATAKAR (Indiana University; Purdue University, Indianapolis) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(Contract F49620-83-K-0034)
(AIAA PAPER 87-0351)

A block-structured solution scheme for the solution of steady Euler equations is presented which has application to the solution of complex fluid mechanics problems using available computer resources including CPU, I/O, memory, and disk facilities. Euler equations are solved in terms of a set of Clebsch variables obtained through the transformation of a velocity vector, and a block-structured relaxation scheme is used to solve the conservation equations for the vector variables. For each variable, the equations are cast in fully implicit form for each block by assuming that the computational grid for each block is unstructured, and a constant-coefficient scheme approximately solves the equations at each step. The balancing of all of the Clebsch variables between neighboring block surfaces is ensured once the equations are solved for each block. R.R.

A87-22576#
AN EFFICIENT EULER SOLVER, WITH MANY APPLICATIONS
GINO MORETTI (G.M.A.F., Inc., Freeport, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0352)

A computational technique for two-dimensional unsteady Euler equations, based on a lambda-formulation and explicit shock fitting, is presented. Any number of shocks, of any shape and type, and their interactions, can be treated by this technique, which does not require a complicated logic and does not perform redundant calculations. The code is fast and the results are very accurate. Examples (transonic airfoils, shocks in ducts, intake flows, multiple Mach reflections) are presented and discussed. Author

A87-22578*# Cornell Univ., Ithaca, N.Y.
A DIAGONAL IMPLICIT MULTIGRID ALGORITHM FOR THE EULER EQUATIONS
DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NAG3-645; NAG2-373)
(AIAA PAPER 87-0354)

A multigrid implementation of the Alternating Direction Implicit algorithm has been developed to solve the Euler equations of inviscid, compressible flow. The equations are approximated using a finite-volume spatial approximation with added dissipation provided by an adaptive blend of second and fourth differences. For computational efficiency, the equations are diagonalized by a local similariity transformation so that only a decoupled system of scalar pentadiagonal systems need be solved along each line. Results are computed for transonic flows past airfoils and include pressure distributions to verify the accuracy of the basic scheme and convergence histories to demonstrate the efficiency of the method. Author

A87-22579*# North Carolina Univ.,. Raleigh.
EULER CALCULATIONS FOR WINGS USING CARTESIAN GRIDS
R. L. GAFFNEY, JR., H. A. HASSAN (North Carolina State University, Raleigh), and M. D. SALAS AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NCC1-22)
(AIAA PAPER 87-0356)

A method is presented for the calculation of transonic flows past wings using Cartesian grids. The calculations are based on a finite volume formulation of the Euler equations. Results are presented for a rectangular wing with a flat tip and the ONERA M6 wing. In general, the results are in good agreement with other computations and available experiment. However, Cartesian grids require a greater number of points than body fitted grids in order to resolve the flow properties near the leading edge of a swept wing. Author

A87-22615#
TRANSONIC VISCOUS FLOW PREDICTIONS WITH THE LOCKHEED NAVIER-STOKES CODE
A. SUGAVANAM (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0410)

An implicit finite-difference code to solve the Reynolds time-averaged compressible Navier-Stokes equations using an Alternate Direction Implicit procedure is described. This code has been applied to obtain solutions past three airfoils in a variety of flow conditions, and the results for the force coefficients, surface pressure distributions and the boundary layer parameters are presented along with experimental correlations. Author

A87-22616#
VISCOUS TRANSONIC FLOW OVER AEROFOILS USING TRANSONIC FULL POTENTIAL EQUATION IN A SYSTEM OF CARTESIAN COORDINATES
S. S. DESAI and R. RANGARAJAN (National Aeronautical Laboratory, Bangalore, India) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. Research supported by the Aeronautical Research and Development Board. refs
(AIAA PAPER 87-0411)

Results are presented here for viscous transonic flow over airfoils to demonstrate the capabilities of a code based on transonic full potential equation in a system of Cartesian coordinates. For this purpose a code based on Carlson's (1976) scheme utilizing Cartesian coordinates has been written, incorporating many improvements apart from incidentally enhancing its computational efficiency. Thus, the improvements in the numerical implementation of the surface boundary condition render the code robust, resulting in an enhanced M-alpha domain in which accurate results can be obtained from the code. Green's lag entrainment method is used along with transpiration model to include viscous effects due to airfoil and wake. An empirical procedure is included to make the drag calculation more realistic. A viscous-ramp model is incorporated to enable cases of strong shock boundary layer interactions to be computed. The code has been validated extensively against experimental results. Author

A87-22617#
VISCOUS TRANSONIC AIRFOIL FLOW SIMULATION BY AN EFFICIENT VISCOUS-INVISCID INTERACTION METHOD
G. DARGEL and P. THIEDE (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. BMFT-supported research. refs
(AIAA PAPER 87-0412)

The viscous-inviscid flow simulation of the present prediction method is based on a defect formulation coupling a transonic full-potential solution for the inviscid flow and a shear-layer integral

solution for the viscous flow. The shock representation in the potential flow is improved by introduction of a shock-point operator satisfying the Prandtl relation across the shock. In regions with strong viscous-inviscid interactions including the wake and flow separations, an inverse-shear-layer integral solution is coupled with the inviscid solution by a semiinverse matching procedure. Special attention is paid to the drag prediction computing the total drag from its components, the momentum and wave drag. Furthermore, a transition strip as well as a base modeling is incorporated. The method is shown to be capable of obtaining reliable results in transonic airfoil flow prediction up to stall conditions (although restricted to small shock-induced separation bubbles) with high efficiency. Author

A87-22618*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF AN UPWIND NAVIER-STOKES CODE TO TWO-DIMENSIONAL TRANSONIC AIRFOIL FLOW
CHRISTOPHER L. RUMSEY, JAMES L. THOMAS, W. KYLE ANDERSON (NASA, Langley Research Center, Hampton, VA), and SHERRIE L. TAYLOR AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 16 p. refs
(AIAA PAPER 87-0413)

An upwind-biased implicit approximate factorization Navier-Stokes algorithm is applied to a variety of steady transonic airfoil cases, using the NACA 0012, RAE 2822, and Jones supercritical airfoils. The thin-layer form of the compressible Navier-Stokes equations is used. Both the CYBER 205 and CRAY 2 supercomputers are utilized, with average computational speeds of about 18 and 16 microsec/gridpoint/iteration, respectively. Lift curves, drag polars, and variations in drag coefficient with Mach number are determined for the NACA 0012 and Jones supercritical airfoils. Also, several cases are computed for comparison with experiment. The effect of grid density and grid extent on a typical turbulent airfoil solution is shown. An algebraic eddy-viscosity turbulence model is used for all of the computations. Author

A87-22619*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A COMPARISON OF TURBULENCE CLOSURE MODELS FOR TRANSONIC FLOWS ABOUT AIRFOILS
LYNDELL S. KING (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0418)

Navier-Stokes transonic airfoil calculations using three different turbulence closure models are presented and compared with available experimental data. Two of the models, Cebeci-Smith and Baldwin-Lomax, are equilibrium models in the sense that the turbulent shear stress is assumed to depend only on the local properties of the mean flow. The third model, Johnson and King, is a nonequilibrium model in which an ordinary differential equation is employed to account for the streamwise development of the maximum Reynolds shear stress. An eddy viscosity distribution across the boundary layer is assumed which is functionally dependent on this stress. For attached flows with little inviscid-viscous interaction, little difference in the results with the different models is noted. With stronger interactions and with separation occurring on the airfoils, the nonequilibrium model is shown to perform better. Author

A87-22620#
NAVIER-STOKES COMPUTATIONS OF TRANSONIC FLOWS USING THE LU-ADI METHOD
KISA MATSUSHIMA (Fujitsu, Ltd., Scientific Systems Dept., Tokyo, Japan), SHIGERU OBAYASHI (Tokyo, University, Japan), and KOZO FUJII (National Aerospace Laboratory, Chofu, Japan) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 24 p. refs
(AIAA PAPER 87-0421)

The 'LANS2D' code is used to simulate the viscous transonic flow fields over the NACA 0012, RAE 2822, and Jones airfoils. The numerical algorithm of the code, the LU-ADI scheme, contains the following options: (1) diagonally dominant L-U factorization, (2) a combined 2nd- and 4th-order dissipation term controlled by the flux limiter, (3) space variable time stepping, and (4) characteristic-like treatment for boundary conditions. It is noted that the scheme is easy to vectorize and can be used efficiently on a supercomputer. K.K.

A87-22621#
COMPUTATIONAL RESULTS FOR VISCOUS TRANSONIC FLOWS AROUND AIRFOILS
WERNER HAASE and HARALD ECHTLE (Dornier GmbH, Friedrichshafen, West Germany) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0422)

For sub- and transonic turbulent flows, solutions of the Navier-Stokes equations are presented. The governing equations are solved by means of a finite volume technique using a Runge-Kutta type time-stepping method. Furthermore, if the flow remains attached, results will be presented based on the coupling of a full potential method with a boundary layer method. Both methods are applied to two-dimensional, adiabatic flows around three different airfoil configurations, i.e., a NACA 0012, a RAE 2822 and a JONES airfoil. Available measurements are used for a verification of the computed results. Author

A87-22622#
ISES - A TWO-DIMENSIONAL VISCOUS AERODYNAMIC DESIGN AND ANALYSIS CODE
MARK DRELA and MICHAEL B. GILES (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract F49620-78-C-0084)
(AIAA PAPER 87-0424)

Viscous airfoil flow predictions using the airfoil design/analysis code ISES are presented. This code employs a zonal representation of the flowfield. The inviscid regions are described by the steady Euler equations discretized on an intrinsic streamline grid. Speed upwinding equivalent to an artificial bulk viscosity is used to stabilize the solution in supersonic regions. The subsonic farfield is represented by vortex, source, and double singularities placed at the airfoil. The supersonic far-field description employs space characteristics to relate the local pressure and flow angle. The boundary layer and wake regions are described by a momentum integral boundary layer formulation with a lag-dissipation closure. The viscous and inviscid regions are coupled via the edge velocity and the displacement thickness concept. The entire nonlinear discrete equation set, which includes the inviscid, viscous, and matching equations, is solved as a fully coupled system by a global Newton method. This solution method is quite fast and is particularly efficient when a parameter sweep, such as a drag polar, is being calculated. Solutions for the Viscous Transonic Airfoil Workshop cases and two low Reynolds number airfoils are presented and compared to experimental data where possible. Author

A87-22623#
TOWARD THE NAVIER-STOKES ANALYSIS OF TRANSPORT AIRCRAFT CONFIGURATIONS
SHIGERU OBAYASHI (Tokyo, University, Japan), KOZO FUJII, and SUSUMU TAKANASHI (National Aerospace Laboratory, Chofu, Japan) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0428)

The viscous transonic flow simulations over ONERA M-5 model are carried out based on the three-dimensional Reynolds-averaged thin-layer Navier-Stokes equations. The LU-ADI factorization algorithm is employed for this study with the use of a nonlinear artificial dissipation term and locally varying time steps. The single grid system in C-O-H topology for the wing-fuselage-tail combination is generated using the analytical method. The computations using 1.5 million of grid points are performed on a supercomputer, Fujitsu VP400. The results proved that the present Navier-Stokes code is

capable of aerodynamic analysis of transport aircraft configurations as a CFD tool. Author

A87-22625*# Douglas Aircraft Co., Inc., Long Beach, Calif.
FURTHER COMPARISONS OF INTERACTIVE BOUNDARY-LAYER AND THIN-LAYER NAVIER-STOKES PROCEDURES
K. C. CHANG, TUNCER CEBECI (Douglas Aircraft Co., Aerodynamics Research and Technology Group, Long Beach, CA), N. ALEMDAROGLU (California State University, Long Beach), and UNMEEL MEHTA (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0430)

Calculations of the flows over NACA 4412 and GA(W)-2 airfoils with low-speed flow and over NACA 0012 and RAE 2822 airfoils with transonic flow are reported. They were obtained by solving potential flow and boundary-layer equations, and by solving thin-layer Navier-Stokes equations. The results cover a range of angles of attack up to and including stall and allow the evaluation of the numerical and physical features of the two solution methods. The agreement with measurements is acceptable except between the results of the thin Navier-Stokes equations and measurements in subsonic flow at high angles of attack. The interactive boundary-layer method is considerably more efficient requiring considerably less computer time and storage. Author

A87-22626#
INVESTIGATING DYNAMIC STALL USING A MODIFIED MOMENTUM-INTEGRAL METHOD
E. J. JUMPER, J. E. HITCHCOCK, R. G. DOCKEN, JR. (USAF, Institute of Technology, Wright-Patterson AFB, OH), and T. S. LAWRENCE (U.S. Army, Aviation Engineering Flight Activity, Edwards AFB, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0431)

A theoretical study of various contributing effects to dynamic stall using a modified momentum-integral method is presented. The development of a closure equation to allow for step-wise integration of the unsteady momentum-integral equation is detailed along with the modification of the method to take into account complications due to a noninertial control volume. The application of the modified method to determine the delay in separation at the quarter chord due to the inclusion of simple unsteadiness, noninertial boundary conditions and the effect of the motion of the wing boundary into the flow is presented. These results are then used to discuss the roll of various causes of dynamic stall previously suggested in the literature. Mass ingestion into the boundary layer due to the motion of the wing into the flow is advanced as an import contributor to dynamic stall and other possible contributors are also discussed. Author

A87-22632#
PASSIVE SHOCK WAVE/BOUNDARY LAYER CONTROL OF A HELICOPTER ROTOR AIRFOIL IN A CONTOURED TRANSONIC WIND TUNNEL
HENRY T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY), TODD J. MITTY, and GREGORY A. NYBERG AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. Army-supported research. refs
(AIAA PAPER 87-0438)

Passive shock wave/boundary layer control for a Bell FX69-H-098 airfoil with a porous surface was investigated in the RPI 3 x 8-inch Blow-Down Transonic Wind Tunnel. A variable-geometry top-wall insert was used to modify the test section flow-field to reduce wall interference and blockage effects indicative of transonic wind-tunnel experimentation. Various insert configurations were examined, and a best-fit geometry was obtained which allowed free-flight conditions to be maintained within the tunnel over the range of Mach numbers used in the investigation. Free-stream Mach numbers as high as 0.866 were observed with the free-flight criteria in effect. Introducing a porous surface extending from 45-75 percent chord resulted in drag reduction of approximately 33 percent at Mach 0.86. Author

A87-22642#
THREE-DIMENSIONAL EULER SOLUTIONS ON BLOCKED GRIDS USING AN IMPLICIT TWO-PASS ALGORITHM
DAVE M. BELK (USAF, Armament Laboratory, Elgin AFB, FL) and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0450)

An unsteady implicit Euler equation solution algorithm using a finite volume discretization and flux-vector splitting is presented. Approximate factorization of the three-dimensional algorithm into two factors results in a two-pass solution scheme where each pass involves solution of a sparse block triangular system of equations. The two-pass algorithm is implemented in a code designed to accent any arrangement of arbitrarily sized grid blocks. The effect of various block-to-block boundary conditions and the location of block boundaries on convergence to steady state is studied by comparing blocked versus unblocked results about a NACA0012 airfoil. Even though convergence is slowed by blocking, the use of blocked grids is economically attractive due to greatly reduced computer memory costs. The code is used to calculate transonic flow over a rectangular supercritical wing of aspect ratio two. Comparison with experimental results for this case is good except at higher Mach numbers where viscous effects are more important. Author

A87-22644*# Princeton Univ., N. J.
IMPROVEMENTS TO THE AIRCRAFT EULER METHOD
A. JAMESON and T. J. BAKER (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 19 p. Research supported by the IBM Corp., U.S. Navy and NASA. refs
(AIAA PAPER 87-0452)

An unstructured mesh of tetrahedra offers an attractive approach to mesh generation for complex three dimensional shapes. The combination of a method for constructing tetrahedral meshes and a finite element technique for solving the Euler equations has resulted in a powerful new approach to the problem of calculating flows over complex geometries. Recent progress and improvements to the authors' aircraft Euler method are described and results presented to demonstrate its capability. Author

A87-22646#
FLOW SIMULATIONS FOR A COMPLEX AIRPLANE CONFIGURATION USING EULER EQUATIONS
N. J. YU, K. KUSUNOSE, H. C. CHEN, and D. M. SOMMERFIELD (Boeing Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. Research supported by the Boeing Independent Research and Development Program. refs
(AIAA PAPER 87-0454)

A new transonic flow analysis program based on the solution of the Euler equations has been developed. The program is capable of analyzing the flow over a complete wing-body-tail-aft-mounted propfan configuration at arbitrarily freestream conditions including sideslip (yaw). Computed results for a transport wing-body-tail configuration, as well as wing-body-tail-aft-mounted propfan configuration with and without propeller are reported in this paper. The capability of analyzing an airplane at yaw is also demonstrated. Author

A87-22647#
A NUMERICAL INVESTIGATION ON WING/NACELLE INTERFERENCES OF USB CONFIGURATION
KEISUKE SAWADA (Kawasaki Heavy Industries Ltd., Gifu, Japan) and SUSUMU TAKANASHI (National Aerospace Laboratory, Tokyo, Japan) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0455)

A numerical investigation on wing/nacelle interferences of USB configuration is carred out by solving the Euler equations. The grid system about the realistic configuration of the complete aircraft is generated by the algebraic method adopting the multi-block transformation technique. The Euler equations are solved by the second order accurate upwind scheme based on the Roe's approximate Riemann solver. Results show fairly complex flow patterns due to the interactions of jet flows exhausted from engine nacelles and also to the existence of channel flows. Comparisons with the experimental data are made which show reasonable agreements. Author

A87-22648#
SPANWISE-PERIODIC 3-D DISTURBANCES IN THE WAKE OF A SLIGHTLY STALLED WING
G. R. INGER (Iowa State University of Science and Technology, Ames) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(Contract AF-AFOSR-85-0357)
(AIAA PAPER 87-0456)

For the case of a slightly aft-stalling large aspect ratio wing in laminar flow, attention is given to the formation and properties of spanwise three-dimensional small disturbances within the boundary layer along the otherwise straight separation line in a nominally two-dimensional flow. Implications for the near wake structure and momentum defect are discussed. It is concluded that the wake vortex structure can have a first order effect on the total momentum defect across the Trefftz Plane. Hence, it is implied that the present separation-originated vortex structure could produce a spanwise periodic variation in drag determination by the wake survey method. K.K.

A87-22650#
AN EXPERIMENTAL INVESTIGATION OF A LAMINAR SEPARATION ON A NATURAL LAMINAR FLOW AIRFOIL
W. A. BELL and K. C. CORNELIUS (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0458)

A separation bubble often exists on high altitude airfoils, for which natural laminar flow extends from 60 to 70 percent of the chord to provide a low drag, high performance airfoil under cruise conditions. A 'short' laminar separation bubble occurring on this type of airfoil is the subject of this paper. Utilizing coincident laser velocimeter (LV) measurements, the mean velocities of the tangential and normal components of the velocity relative to the airfoil surface and the two-dimensional Reynolds stress tensor were measured at designated chord locations throughout the separated region. The data show the essential features of the bounded shear layer as it transitions above the recirculation zone. The mean momentum transfer influenced by the Reynolds stress production represents the dominant feature in the reattachment region. The LV measurements provide insight into the physical processes as the boundary layer transitions to a fully developed, turbulent profile downstream. Author

A87-22664#
SIMULATION OF EXTERNAL FLOWFIELDS USING A THREE-DIMENSIONAL EULER/NAVIER-STOKES ALGORITHM
JOSEPH VADYAK, MARILYN J. SMITH, DAVID M. SCHUSTER, and RICHARD WEED (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. Research supported by the Lockheed Independent Research and Development Program. refs
(AIAA PAPER 87-0484)

An analysis is presented for calculating steady (or unsteady) three-dimensional aircraft external flowfields. This algorithm can compute the flowfield about wing, fuselage, and wing/fuselage configurations at zero or nonzero incidence at subsonic, transonic, or supersonic free-stream speeds. The algorithm can solve either the Euler momentum equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit algorithm is employed for solution of the finite-difference equations. Viscous flow results are presented to illustrate application of the analysis fow cases at subsonic, transonic, and supersonic free-stream speeds. Author

A87-22682*# Air Force Armament Lab., Eglin AFB, Fla.
A STUDY OF MULTI-BODY AERODYNAMIC INTERFERENCE AT TRANSONIC MACH NUMBERS
CHARLES J. COTTRELL, AGUSTO MARTINEZ (USAF, Armament Laboratory, Eglin AFB, FL), and GARY T. CHAPMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0519)

A wind tunnel experiment involving single, double, and triple combinations of mutually interfering generic, unfinned aircraft stores has been conducted. Each combination of stores was tested at Mach numbers from 0.60 to 1.20 and at angles of attack from 0 to 25 deg for the single store and from 0 to 6 deg for the double and triple store configurations. Extensive axial and circumferential pressure and flow visualization data at each store location were obtained. Euler solutions for each configuration at 0 deg incidence have been generated and compared with experimental data. This comparison indicates an Euler flow solver can yield accurate predictions of the location and magnitude of multibody interference provided an appropriate grid is used and the viscous effects associated with these configurations remain small. The data indicate multibody interference in the transonic region increases as the freestream Mach number approaches 1 from either direction, and subsides as the Mach number moves away from sonic conditions. This interference is characterized by a large, localized reduction in pressure on the inboard surfaces of the bodies which results in forces that draw the configuration closer together. Author

A87-22684
AN EULER CORRECTION METHOD FOR TWO- AND THREE-DIMENSIONAL TRANSONIC FLOWS
THONG Q. DANG and LEE-TZONG CHEN (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
(Contract N00167-85-C-0134)
(AIAA PAPER 87-0522)

A method, based on the Clebsch transformation, has been developed to solve the steady Euler equations for transonic flows about airfoils and wing/bodies. In the Clebsch transformation, the velocity is decomposed into irrotational and rotational components. A modified version of an existing finite-volume full-potential method is used to compute the potential part, while the rotational parts are determined from the momentum equation. The solutions obtained for airfoils and wing/bodies are compared with those obtained using the time-marching Euler methods. Except near the

wing tip, agreements between these two solutions are very good. Author

A87-22685*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EULER SOLUTION OF THE TRANSONIC FLOW FOR A HELICOPTER ROTOR
I-CHUNG CHANG (NASA, Ames Research Center, Moffett Field, CA) and CHEE TUNG (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0523)

A new method is presented for calculating the quasi-steady transonic flow over a lifting or nonlifting rotor blade in both hover and forward flight by using Euler equations. The approach is to solve the Euler equations in a rotor-fixed frame of reference using a finite volume method. A computer program was developed and was then verified by comparison with wind-tunnel data. In all cases considered, good agreement was found with available experimental data. Author

A87-22686
SEARCHING THE HORIZON OF NAVIER-STOKES SIMULATION OF TRANSONIC AIRCRAFT
J. MIYAKAWA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan), S. TAKANASHI, K. FUJII (National Aerospace Laboratory, Tokyo, Japan), and K. AMANO (Japan Aircraft Development Corp., Tokyo) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. refs
(AIAA PAPER 87-0524)

A three-dimensional Navier-Stokes code (LANS3D) is validated in terms of the analysis of a wing-body configuration of a practical transonic aircraft by comparison to a wind tunnel test. The comparison is carried out at a Reynolds number of 2.2 million which corresponds to the wind tunnel test. The agreements are satisfactory in both aerodynamic forces and surface pressure so that the code is concluded to be a very effective tool to predict nonlinear characteristics of transonic wing-body configurations. This validation work is a small but great step toward the horizon of Navier-Stokes simulation of a complete configuration of transonic aircraft. Author

A87-22691*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ALGORITHM DEVELOPMENTS FOR THE EULER EQUATIONS WITH CALCULATIONS OF TRANSONIC FLOWS
PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0536)

A new algorithm has been developed for the Euler equations that uses flux vector splitting in combination with the concept of rotating the coordinate system to the local streamwise direction. Flux vector biasing is applied along the local streamwise direction and central differencing is used transverse to the flow direction. The flux vector biasing is switched from upwind for supersonic flow to downwind-biased for subsonic flow. This switching is based on the Mach number; hence the proper domain of dependence is used in the supersonic regions and the switching occurs across shock waves. The theoretical basis and the development of the formulas for flux vector splitting are presented. Then several one-dimensional calculations are presented of steady and unsteady transonic flows, which demonstrate the stability and accuracy of the algorithm. Finally results are shown for unsteady transonic flow over an airfoil. The pressure coefficient plots show sharp transonic shock profiles, and the Mach contour plots show smoothly varying contours. Author

A87-22723*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STRAKE-GENERATED VORTEX INTERACTIONS FOR A FIGHTER-LIKE CONFIGURATION
STEVEN G. REZNICK (NASA, Ames Research Center, Moffett Field, CA) and JOLEN FLORES AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 26 p. refs
(AIAA PAPER 87-0589)

A combination of the Euler, and thin-layer Navier-Stokes equations were solved for the flowfield around a wing-strake-fuselage configuration similar to the F-16A aircraft. The flowfield was divided into multiple blocks using a zoning program, and the TNSWF solution program, based on an implicit solution algorithm, updates each subregion of the flowfield sequentially. The total grid contained approximately 300,000 grid points, and clustering was effected normal to all aircraft surfaces. The computed solutions agreed well quantitatively with wind-tunnel pressure distribution data, and they agreed well qualitatively with flow visualization from wind- and water-tunnel tests. Author

A87-22724#
APPLICATIONS OF TWO- AND THREE-DIMENSIONAL INTERACTIVE BOUNDARY-LAYER THEORY TO FINITE WINGS WITH FLOW SEPARATION
TUNCER CEBECI, K. C. CHANG, R. W. CLARK (Douglas Aircraft Co., Long Beach, CA), and D. SEDLOCK (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract F33615-83-C-3026)
(AIAA PAPER 87-0590)

An interactive viscous/inviscid procedure has been developed combining a three-dimensional panel method with an inverse finite-difference boundary-layer method. The scheme incorporates both a two-dimensional and a quasi-three-dimensional boundary-layer scheme. The resulting method has been applied to the calculation of the flow over three-dimensional wings and wing-body configurations, and it has been shown that the procedure can compute flows with significant regions of boundary-layer separation. Author

A87-22725*# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
A GLOBAL MARCHING TECHNIQUE FOR THE PREDICTION OF SEPARATED FLOWS OVER ARBITRARY AIRFOILS
AHMAD A. M. HALIM (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NAG1-573)
(AIAA PAPER 87-0591)

The flow over arbitrary airfoils is analyzed using a boundary-layer-type solver developed for studying separated flows. The scheme includes extension to a general coordinate system and use of a more general zonal technique for solving the coupled equations. In order to be able to consider arbitrary geometries, second order accurate (in space) conservative differences are generated by considering the integral formulation of the governing equations in a general coordinate system. The general coordinate system is handled in as general a manner as possible to allow for the use of either analytically or numerically generated coordinate system. Different C type grids (orthogonal and nonorthogonal) were generated using different grid generation techniques to analyze the flow over arbitrary airfoils (J012, J025, NACA0012). A comparison with the experiment is demonstrated. Author

A87-22734#
A HODOGRAPH-BASED METHOD FOR THE DESIGN OF SHOCK-FREE CASCADES
A. A. HASSAN (Arizona State University, Tempe) and G. S. DULIKRAVICH (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0606)

A hodograph-based method, originally developed by Hassan (1981) for the design of shock-free airfoils, has been modified and extended to allow for the design of shock-free compressor blades. In the present procedure, the subsonic and supersonic regions of the flow are decoupled, allowing the solution of either an elliptic or hyperbolic-type partial differential equation for the stream function. The coupling of both regions of the flow is carried out along the sonic line which adjoins both regions. Examples of shock-free compressor blade designs are presented. They show good agreement with the direct computation of the flow past the designed blade. Author

A87-22735#
NUMERICAL AND EXPERIMENTAL INVESTIGATION OF A PROPELLER FLOWFIELD WITH A 3-D NON-UNIFORM INFLOW
JOSEPH A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg), DAVID A. MALLORY (General Electric Co., Lynn, MA), and DOMINIQUE PELLETIER (Montreal, Universite, Canada) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. Navy-supported research. refs
(AIAA PAPER 87-0607)

A three-dimensional flow field produced by a three-bladed propeller operating in an approach flow representative of flows encountered in pusher-prop arrangements on aircraft or underwater vehicles was studied numerically and experimentally. The test apparatus consisted of a propeller rig for measuring the overall rotor performance, and a screen disk, which imposed a nonuniform approach flow on the propeller, similar to the wake behind a slender axisymmetric body with a slender planar appendage. In the computational part, the fully elliptic three-dimensional Reynolds-averaged steady-state primitive-variable Navier-Stokes equations were solved by a penalty FEM. The results were compared with the predictions obtained from turbulence modeling, performed through a generalization of the integrated TKE model. The agreement achieved is considered to be excellent. I.S.

A87-22754#
EVALUATION OF A RESEARCH CIRCULATION CONTROL AIRFOIL USING NAVIER-STOKES METHODS
GEORGE D. SHREWSBURY (Lockheed-Georgia Co., Advanced Flight Sciences Dept., Marietta, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0002)

The compressible Reynolds time averaged Navier-Stokes equations were used to obtain solutions for flows about a two-dimensional circulation control airfoil. The governing equations were written in conservation form for a body-fitted coordinate system and solved using an Alternating Direction Implicit (ADI) procedure. A modified algebraic eddy viscosity model was used to define the turbulent characteristics of the flow, including the wall jet flow over the Coanda surface at the trailing edge. Numerical results are compared to experimental data obtained for a research circulation control airfoil geometry. Excellent agreement with the experimental results was obtained. Author

A87-22755*# Old Dominion Univ., Norfolk, Va.
NUMERICAL SOLUTIONS OF NAVIER-STOKES EQUATIONS FOR A BUTLER WING
JAMSHID S. ABOLHASSANI, SURENDRA N. TIWARI (Old Dominion University, Norfolk, VA), and ROBERT E. SMITH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(Contract NCC1-68)
(AIAA PAPER 87-0115)

The flow field is simulated on the surface of a Butler wing in a uniform stream. Results are presented for Mach number 3.5 and Reynolds number of 2,000,000. The simulation is done by integrating the viscous Navier-Stokes equations. These equations govern the unsteady, viscous, compressible and heat conducting flow of an ideal gas. The equations are written in curvilinear coordinates so that the wing surface is represented accurately. The O-type and H-type grids have been used for this study, and results are compared. The governing equations are solved by the MacCormack time-split method, and the results are compared with other theoretical and experimental results. The codes are written in FORTRAN, vectorized and currently run on the CDC Vector Processing System (VPS-32) computer. Author

A87-22929*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LOW ASPPECT RATIO WINGS AT HIGH ANGLES OF ATTACK
R. L. STALLINGS, JR. (NASA, Langley Research Center, Hampton, VA) IN: Tactical missile aerodynamics . New York, American Institute of Aeronautics and Astronautics, 1986, p. 89-128. refs

A comprehensive evaluation is made of experimental data compiled to date for the flowfields and aerodynamic forces that occur at high angles of attack for low aspect ratio wings with delta, rectangular, clipped delta, and strake/wing planform geometries. Attention is given to wing leading edge-generated vortex breakdown, aspect ratio and compressibility effects, and strake vortex effects on main wing areas. Although the nonlinear effects created by a wing-body combination significantly alter wing-alone aerodynamics, the wing-alone data presented are vital to the development of prediction methodologies for large angle of attack aerodynamics. O.C.

A87-22953#
AN EFFICIENT TIME-MARCHING SCHEME FOR SOLVING COMPRESSIBLE EULER EQUATIONS
HISAAKI DAIGUJI (Tohoku University, Sendai, Japan) and SATORU YAMAMOTO JSME, Bulletin (ISSN 0021-3764), vol. 29, Sept. 1986, p. 2845-2850. refs

An implicit time-marching finite difference scheme is proposed for analyzing steady two-dimensional inviscid transonic flows. The scheme is based on the well-known Beam-Warming delta-form approximate factorization scheme, but this is improved in the following two points: (1) in order to treat the fixed wall boundary condition without difficulty, momentum equations of contravariant velocity components as fundamental equations in curvilinear coordinates are used; and (2) to calculate stably with a sufficiently large Courant number, the central-difference of the Crank-Nicholson method is replaced by the upstream-difference of the Robert-Weiss method. The upstreaming is performed on the basis of the theory of characteristics and does not influence the accuracy of the solution. The flows through a converging-diverging nozzle and a symmetric wing are calculated. The calculated results agree well with the existing theories. Author

A87-23234*# Technische Hochschule, Aachen (West Germany).
INITIATION OF BREAKDOWN IN SLENDER COMPRESSIBLE VORTICES
E. KRAUSE, S. MENNE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Chinese Aerodynamics Research Society, International Conference on Numerical Methods in Fluid Dynamics, 10th, Beijing, People's Republic of China, June 23-27, 1986, Paper. 6 p.

The initiation of the breakdown process for axially symmetric compressible flows is investigated using a numerical solution of the conservation equations for mass, momentum, and energy. The vortex is isolated, with its axis parallel to the direction of the main stream, and the core radius is small compared to the breakdown length. Computations for several flowfields indicate that the breakdown of the solution is shifted further downstream with increasing Mach number until breakdown is no longer observed. In the subsonic case, the influence of the initial temperature distribution on the breakdown length of the solution is more pronounced than in the supersonic case, with heating of the core enhancing breakdown, and cooling delaying it. The breakdown of the solution is seen to always occur for nonvanishing axial velocity components. R.R.

A87-23284
COMPUTATIONS OF SUPERSONIC FLOW PAST LIFTING BODIES
P. I. CHUSHKIN and G. P. VOSKRESENSKII IN: Current problems in computational fluid dynamics . Moscow, Mir Publishers, 1986, p. 71-124. Translation. refs

Numerical methods for computing three-dimensional supersonic flow past aircraft and spacecraft are reviewed. The principles and properties of the finite-difference grid methods, the methods of characteristics, the method of integral relations, and the method of straight lines are described. The methods are applied to the calculation of various cases of supersonic flow past bodies at an angle of attack; numerical calculations for aerodynamic forms which simulate whole or individual components of aircraft are presented. Supersonic flow of a perfect gas with a constant adiabatic exponent and gas with equilibrium or nonequilibrium physical and chemical properties are examined. Graphs representing the flow pattern and the behavior of aerodynamic characteristics of bodies under various flight conditions are provided. I.F.

N87-15166# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Design Aerodynamics.
THE INFLUENCE OF TRANSITION STRIPS ON THE PRESSURE DISTRIBUTION ON TRANSONIC PROFILES
R. MUELLER *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 89-99 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23718
Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

Transonic wind tunnel tests were performed to determine the influence of transition strips on pressure distribution. Measurements were performed on three transport aircraft profiles, covering the Mach number range from 0.70 to 0.80. The transition strips are produced with Korund grain 220 K according to the DFVLR-TWB standard method and have a width of 1% of the model profile depth. The influence of the strips on the upper surface of the profile is extremely large, even for downstream, and also for high Reynolds numbers. The influence on the lower surface in the rear loading domain strongly decreases for high Reynolds numbers. The Reynolds number effect in free transition is orders of magnitude lower. At constant Reynolds number an increasing Mach number enhances the influence on the rear loading of the lower surface. The influence of the strips on the pressure distribution is shown for several cases. ESA

N87-15168# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. of Aerothermodynamics.
INVESTIGATION OF THE CONDITIONS FOR TRIPPING TRANSITION WITH ROUGHNESS ELEMENTS AND THEIR INFLUENCE ON BOUNDARY LAYER DEVELOPMENT
R. MICHEL and D. ARNAL *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 103-113 Oct. 1985 Transl. into ENGLISH from "Grenzxchichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23720
Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

Boundary layer tripping with transverse wires at carborundum bands, in zero and nonzero pressure gradients, were experimentally studied using a flat plate in incompressible flow, for a great number of tripping devices. It appears that high turbulence intensities are not created on the roughness itself, but rather in the downstream separated region. The critical grain size required for fixing transition at the roughness location is plotted. Increasing the grain size produces an overthickness of the boundary layer due to the roughness drag. The drag coefficient increases when the roughness height is larger than the boundary layer thickness. Similar results are obtained in negative and positive pressure gradients. Applications on wing profiles in incompressible and compressible flows are presented. ESA

N87-15169# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Experimentelle Stroemungsmechanik.
TRANSITION FIXING AND SIMULATION OF HIGH REYNOLDS NUMBER FLOW AT TRANSONIC VELOCITIES
E. STANEWSKY *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 115-129 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23721
Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

The simulation of two-dimensional high Reynolds flow was investigated. Airfoil tests up to relatively high Reynolds numbers, using airfoils of various sensitivities to Reynolds number changes, show that the initial displacement thickness has a dominant influence on the flow development about transonic airfoils. The duplication of the initial displacement thickness seems adequate to simulate high Reynolds number flow with shock waves, at least for free stream conditions without excessive separated regions. The possible errors associated with such a simulation and the simultaneous simulation of all aerodynamic parameters are considered. This simulation seems to be applicable to separated flow. It is concluded that the method allows simulation of two-dimensional high Reynolds number flow. ESA

N87-15173*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VISCOUS ANALYSES FOR FLOW THROUGH SUBSONIC AND SUPERSONIC INTAKES
LOUIS A. POVINELLI and CHARLES E. TOWNE 9 Sep. 1986 24 p Presented at the AGARD Propulsion and Energetics Panel Meeting on Engine Response to Distorted Inflow Conditions, Munich, Germany, 8-9 Sep. 1986
(NASA-TM-88831; E-3209; NAS 1.15:88831) Avail: NTIS HC A02/MF A01 CSCL 01A

A parabolized Navier-Stokes code was used to analyze a number of diffusers typical of a modern inlet design. The effect of curvature of the diffuser centerline and transitioning cross sections was evaluated to determine the primary cause of the flow distortion in the duct. Results are presented for S-shaped intakes with circular and transitioning cross sections. Special emphasis is placed on verification of the analysis to accurately predict distorted flow fields resulting from pressure-driven secondary flows. The effect of vortex generators on reducing the distortion of intakes is presented. Comparisons of the experimental and analytical total pressure

contours at the exit of the intake exhibit good agreement. In the case of supersonic inlets, computations of the inlet flow field reveal that large secondary flow regions may be generated just inside of the intake. These strong flows may lead to separated flow regions and cause pronounced distortions upstream of the compressor.
Author

N87-15174*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICABILITY OF LINEARIZED-THEORY ATTACHED-FLOW METHODS TO DESIGN AND ANALYSIS OF FLAP SYSTEMS AT LOW SPEEDS FOR THIN SWEPT WINGS WITH SHARP LEADING EDGES
HARRY W. CARLSON and CHRISTINE M. DARDEN Jan. 1987 54 p
(NASA-TP-2653; L-16151; NAS 1.60:2653) Avail: NTIS HC A04/MF A01 CSCL 01A

Low-speed experimental force and data on a series of thin swept wings with sharp leading edges and leading and trailing-edge flaps are compared with predictions made using a linearized-theory method which includes estimates of vortex forces. These comparisons were made to assess the effectiveness of linearized-theory methods for use in the design and analysis of flap systems in subsonic flow. Results demonstrate that linearized-theory, attached-flow methods (with approximate representation of vortex forces) can form the basis of a rational system for flap design and analysis. Even attached-flow methods that do not take vortex forces into account can be used for the selection of optimized flap-system geometry, but design-point performance levels tend to be underestimated unless vortex forces are included. Illustrative examples of the use of these methods in the design of efficient low-speed flap systems are included.
Author

N87-15175*# McDonnell-Douglas Helicopter Co., Mesa, Ariz.
APPLICATION OF HIGHER HARMONIC BLADE FEATHERING ON THE OH-6A HELICOPTER FOR VIBRATION REDUCTION Final Report
F. K. STRAUB and E. V. BYRNS, JR. Washington NASA 1986 190 p
(Contract NAS1-16266)
(NASA-CR-4031; NAS 1.26:4031) Avail: NTIS HC A09/MF A01 CSCL 01A

The design, implementation, and flight test results of higher harmonic blade feathering for vibration reduction on the OH-6A helicopter are described. The higher harmonic control (HHC) system superimposes fourth harmonic inputs upon the stationary swashplate. These inputs are transformed into 3P, 4P and 5P blade feathering angles. This results in modified blade loads and reduced fuselage vibrations. The primary elements of this adaptive vibration suppression system are: (1) acceleration transducers sensing the vibratory response of the fuselage; (2) a higher harmonic blade pitch actuator system; (3) a flightworthy microcomputer, incorporating the algorithm for reducing vibrations, and (4) a signal conditioning system, interfacing between the sensors, the microcomputer and the HHC actuators. The program consisted of three distinct phases. First, the HHC system was designed and implemented on the MDHC OH-6A helicopter. Then, the open loop, or manual controlled, flight tests were performed, and finally, the closed loop adaptive control system was tested. In 1983, one portion of the closed loop testing was performed, and in 1984, additional closed loop tests were conducted with improved software. With the HHC system engaged, the 4P pilot seat vibration levels were significantly lower than the baseline ON-6A levels. Moreover, the system did not adversely affect blade loads or helicopter performance. In conclusion, this successful proof of concept project demonstrated HHC to be a viable vibration suppression mechanism.
Author

N87-15176*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EFFICIENT ALGORITHM FOR SOLUTION OF THE UNSTEADY TRANSONIC SMALL-DISTURBANCE EQUATION
JOHN T. BATINA Dec. 1986 14 p Proposed for presentation at the AIAA 25th Aerospace Sciences Meeting
(NASA-TM-89014; NAS 1.15:89014; AIAA-86-0109) Avail: NTIS HC A02/MF A01 CSCL 01A

A time accurate approximate factorization (AF) algorithm is formulated for solution of the three dimensional unsteady transonic small-disturbance equation. The AF algorithm consists of a time linearization procedure coupled with a Newton iteration technique. Superior stability characteristics of the new algorithm are demonstrated through applications to steady and oscillatory flows at subsonic and supersonic freestream conditions for an F-5 fighter wing. For steady flow calculations, the size of the time step is cycled to achieve rapid convergence. For unsteady flow calculations, the AF algorithm is sufficiently robust to allow the step size to be selected based on accuracy rather than on stability considerations. Therefore, accurate solutions are obtained in only several hundred time steps yielding a significant computational cost savings when compared to alternative methods.
Author

N87-15178*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A COMPARISON OF THE ACOUSTIC AND AERODYNAMIC MEASUREMENTS OF A MODEL ROTOR TESTED IN TWO ANECHOIC WIND TUNNELS
D. A. BOXWELL (Army Aviation Research and Technology Activity, Cleveland, Ohio), F. H. SCHMITZ, W. R. SPLETTSTOESSER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany), K. J. SCHULTZ, S. LEWY (Office National d'Etudes et de Recherches Aeronautiques, Paris, France), and M. CAPLOT Nov. 1986 56 p Presented at the 12th European Rotorcraft Forum, Garmisch-Partenkirchen, West Germany, Sep. 1986
(NASA-TM-88364; A-86417; NAS 1.15:88364; USAAVSCOM-TM-86-A-6; PAPER-38-1) Avail: NTIS HC A04/MF A01 CSCL 01A

Two aeroacoustic facilities--the CEPRA 19 in France and the DNW in the Netherlands--are compared. The two facilities have unique acoustic characteristics that make them appropriate for acoustic testing of model-scale helicopter rotors. An identical pressure-instrumented model-scale rotor was tested in each facility and acoustic test results are compared with full-scale-rotor test results. Blade surface pressures measured in both tunnels were used to correlated nominal rotor operating conditions in each tunnel, and also used to assess the steadiness of the rotor in each tunnel's flow. In-the-flow rotor acoustic signatures at moderate forward speeds (35-50 m/sec) are presented for each facility and discussed in relation to the differences in tunnel geometries and aeroacoustic characteristics. Both reports are presented in appendices to this paper. ;.);
Author

N87-15179*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
UNSTEADY AERODYNAMIC LOAD ESTIMATES ON TURNING VANES IN THE NATIONAL FULL-SCALE AERODYNAMIC COMPLEX
THOMAS R. NORMAN Dec. 1986 75 p
(NASA-TM-88191; A-86015; NAS 1.15:88191) Avail: NTIS HC A04/MF A01 CSCL 01A

Unsteady aerodynamic design loads have been estimated for each of the vane sets in the National Full-Scale Aerodynamic Complex (NFAC). These loads include estimates of local loads over one vane section and global loads over an entire vane set. The analytical methods and computer programs used to estimate these loads are discussed. In addition, the important computer input parameters are defined and the rationale used to estimate them is discussed. Finally, numerical values are presented for both the computer input parameters and the calculated design loads for each vane set.
Author

N87-15180*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A WING-CANARD CONFIGURATION WITH UNDERWING SPANWISE BLOWING ON THE TRAILING-EDGE FLAP SYSTEM
DANIEL W. BANKS and JOHN W. PAULSON, JR. Jan. 1987 115 p
(NASA-TM-89020; L-16161; NAS 1.15:89020) Avail: NTIS HC A06/MF A01 CSCL 01A

An investigation of the effects of spanwise blowing applied to the lower surface of a trailing-edge flap system on a wing-canard configuration has been conducted in the Langley 4- by 7-Meter Tunnel. The investigation studied spanwise-blowing angles of 30 deg., 45 deg., and 60 deg. measured from a perpendicular to the body center-line. The test conditions covered a range of free-stream dynamic pressures up to 50 psf for thrust coefficients up to 2.1 over a range of angles of attack from -2 deg. to 26 deg. Model height above the wind tunnel floor was varied from a height-to-span ratio of 1.70 down to 0.20 (a representative wheel touchdown height). The results indicate that blowing angles of 30 deg. and 45 deg. increase the induced-lift increment produced by spanwise blowing on the lower surface of a trailing-edge flap system. Increasing the blowing angle to 60 deg., in general, produces little further improvement. Author

N87-15181*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AGARD FLUID DYNAMICS PANEL SYMPOSIUM ON APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS IN AERONAUTICS: PROCEEDINGS
W. J. MCCROSKEY Dec. 1986 19 p Symposium held in Aix-en-Provence, France, 7-10 Apr. 1986
(NASA-TM-88356; A-86399; NAS 1.15:88356) Avail: NTIS HC A02/MF A01 CSCL 01A

The Fluid Dynamics Panel of AGARD arranged a Symposium on Applications of Computational Fluid Dynamics in Aeronautics, on 7 to 10 April 1986 in Aix-en-Provence, France. The purpose of the Symposium was to provide an assessment of the status of CFD in aerodynamic design and analysis, with an emphasis on emerging applications of advanced computational techniques to complex configurations. Sessions were devoted specifically to grid generation, methods for inviscid flows, calculations of viscous-inviscid interactions, and methods for solving the Navier-Stokes equations. The 31 papers presented at the meeting are published in AGARD Conference Proceedings CP-412 and are listed in the Appendix of this report. A brief synopsis of each paper and some general conclusions and recommendations are given. Author

N87-15182*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC CHARACTERISTICS OF TWO-DIMENSIONAL WING CONFIGURATIONS AT ANGLES OF ATTACK NEAR -90 DEG
MARTIN MAISEL, GEORGENE LAUB, and W. J. MCCROSKEY Dec. 1986 84 p
(NASA-TM-88373; A-86427; NAS 1.15:88373; USAAVSCOM-TM-86-A-8) Avail: NTIS HC A05/MF A01 CSCL 01A

Wind tunnel tests were conducted to determine the drag of two-dimensional wing sections operating in a near-vertical flow condition. Various leading- and trialing-edge configurations, including plain flaps of 25, 30, and 35% chord were tested at angles of attack from -75 to -105 deg. Reynolds numbers examined ranged from approximately 0.6 x 10 to the 6th power to 1.4 x 10 to the 6th power. The data were obtained using a wind tunnel force and moment balance system and arrays of chordwise pressure orifices. The results showed that significant reductions in drag, beyond what would be expected by virtue of the decreased frontal area, were obtainable with geometries that delayed flow separation. Rapid changes in drag with angle of attack were noted for many configurations. The results, however, were fairly insensitive to Reynolds number variations. Drag values computed from the pressure data generally agreed with the force data within 2%. Author

N87-15184*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUBSONIC MANEUVER CAPABILITY OF A SUPERSONIC CRUISE FIGHTER WING CONCEPT
GREGORY D. RIEBE and CHARLES H. FOX, JR. Jan. 1987 74 p
(NASA-TP-2642; L-16097; NAS 1.60:2642) Avail: NTIS HC A04/MF A01 CSCL 01A

A theoretical and experimental investigation was conducted of the subsonic maneuver capability of a fighter wing concept designed for supersonic cruise. To improve the subsonic maneuver capability, the wing utilized full-span leading- and trailing-edge flaps that were designed with the aid of a subsonic-analysis computer program. Wind-tunnel tests were made at Mach numbers of 0.3, 0.5, and 0.7. Force and moment data obtained were compared with theoretical predictions of Mach 0.5 from two subsonic-analysis computer programs. The two theoretical programs gave a good prediction of the lift and drag characteristics but only a fair prediction of the pitching moment. The experimental results of this study show that with the proper combination of leading- and trailing-edge flap deflections, a suction parameter of nearly 90 percent can be attained at a Mach number of 0.5 and a lift coefficient of 0.73; this is a three-fold improvement from 30 percent for the basic wing. Author

N87-15185*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PRELIMINARY STUDY OF A WING-TIP VORTEX USING LASER VELOCIMETRY
R. K. TAKAHASHI and K. W. MCALISTER Jan. 1987 34 p
(NASA-TM-88343; A-86207; NAS 1.15:88343; AVSCOM-TM-86-A-2) Avail: NTIS HC A03/MF A01 CSCL 01A

Measurements have been made in the wake of a semi-span NACA 0015 airfoil with emphasis on the region of the wing tip vortex. The spanwise and streamwise velocity components were measured using a two-component laser Doppler velocimeter. The purpose of the study was to initiate the operation of a laser velocimeter system and to perform preliminary wake measurements in preparation for a more extensive study of the structure and near field development of a tip vortex. Author

N87-15186*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
TRANDESNF: A COMPUTER PROGRAM FOR TRANSONIC AIRFOIL DESIGN AND ANALYSIS IN NONUNIFORM FLOW
J. F. CHANG and C. EDWARD LAN Washington NASA Jan. 1987 70 p
(Contract NAG1-308)
(NASA-CR-4044; NAS 1.26:4044; KU-FRL-602-1) Avail: NTIS HC A04/MF A01 CSCL 01A

The use of a transonic airfoil code for analysis, inverse design, and direct optimization of an airfoil immersed in propfan slipstream is described. A summary of the theoretical method, program capabilities, input format, output variables, and program execution are described. Input data of sample test cases and the corresponding output are given. Author

N87-15187*# Old Dominion Univ., Norfolk, Va. Research Foundation.
A SIMPLIFIED FOURWALL INTERFERENCE ASSESSMENT PROCEDURE FOR AIRFOIL DATA OBTAINED IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
A. V. MURTHY Washington NASA Jan. 1987 59 p
(Contract NAG1-334)
(NASA-CR-4042; NAS 1.26:4042) Avail: NTIS HC A04/MF A01 CSCL 01A

A simplified fourwall interference assessment method has been described, and a computer program developed to facilitate correction of the airfoil data obtained in the Langley 0.3-m Transonic

Cryogenic Tunnel (TCT). The procedure adopted is to first apply a blockage correction due to sidewall boundary-layer effects by various methods. The sidewall boundary-layer corrected data are then used to calculate the top and bottom wall interference effects by the method of Capallier, Chevallier and Bouinol, using the measured wall pressure distribution and the model force coefficients. The interference corrections obtained by the present method have been compared with other methods and found to give good agreement for the experimental data obtained in the TCT with slotted top and bottom walls. Author

N87-15189# Grumman Aerospace Corp., Bethpage, N.Y.
CANARD/TAIL TRANSONIC ANALYSIS Final Technical Report, Jun. 1981 - Jun. 1985
P. AIDALA Oct. 1985 123 p
(Contract F33615-81-C-3013)
(AD-A171075; AFWAL-TR-85-3087) Avail: NTIS HC A06/MF A01 CSCL 20D

The theoretical and operational characteristics of the CANTATA code are described. The code provides 3 D transonic analysis of wing-body-canard or wing-body-tail configurations. The relative placement of the two lifting surfaces is arbitrary. The potential flow solution of the code uses a new ADI algorithm, AF2YZ. The algorithm is a three step procedure which uses a split streamwise operator, with a simple factorization of the cross-plane terms. The analysis includes the ability to allow the vortex sheets from the lifting surfaces to move under the influence of the local velocity. Wake rollup is modeled by merging vortex lines such that a single-valued spanwise shape is maintained. Viscous effects are included through the use of a strip boundary layer method. The overall code includes a numerical optimization routine that can be used to alter the lifting surface geometry in an automated design procedure. GRA

N87-15190# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
WIND TUNNEL DATA FROM A ROTOR WAKE/AIRFRAME INTERACTION STUDY Interim Technical Report
A. G. BRAND, N. M. KOMERATH, and H. M. MCMAHON Jul. 1986 103 p
(Contract DAAG29-82-K-0094)
(AD-A171333; ARO-19364.18-EG-RW) Avail: NTIS HC A06/MF A01 CSCL 01A

Accurate prediction and understanding of the aerodynamic interactions between a rotor and airframe are essential to the improvement of future rotorcraft. Large amounts of energy are added by the lifting rotor to an otherwise uniform free stream. The resulting wake flow interaction with the airframe has led to problems in dynamics, performance, acoustics and handling qualities. The interaction phenomena associated with a rotor/airframe in forward flight are currently under study as part of a research effort in the Rotary Wing Technology Center sponsored by the U.S. Army at Georgia Tech. The objective of this program is the systematic measurement of interaction effects and the validation of prediction codes using these measurements. This report presents the aerodynamic interaction data base that has been generated in experiments conducted in the John J. Harper 7x9-foot wind tunnel at Georgia Tech. It is hoped that these results will be useful as a guide in the development of prediction codes as well as providing a test for their validity Author (GRA)

N87-15191# Ballistic Research Labs., Aberdeen Proving Ground, Md.
DRAG PREDICTIONS FOR PROJECTILES AT TRANSONIC AND SUPERSONIC SPEEDS Final Report
JUBARAJ SAHU Jun. 1986 49 p
(AD-A171462; AD-F300785; BRL-MR-3523) Avail: NTIS HC A03/MF A01 CSCL 20D

The breakdown of the total drag into its individual components (pressure drag, viscous drag, and base drag) is important in the preliminary design stage of a shell. Design codes are available to predict the individual drag components and thus, the total drag. Typically, the total drag predicted by these design codes agrees well with the total drag measured from flight tests. But, how well do these codes predict the individual drag components? Experimental verification of the prediction of the drag components is an extremely difficult task. Thus a Navier-Stokes computational procedure is used in this report to predict the individual drag components and test the accuracy of the predictions of the design codes. A thin-layer Navier-Stokes code has been used to compute the entire flow field over projectiles including the base region. Numerical calculations have been made for various Mach numbers in the transonic and supersonic regimes. Pressure drag, skin friction drag, base drag and thus, the total drag are obtained from the computed results. Comparison of drag has been made with available experimental data and also with predictions from design codes employing semi-empirical techniques. GRA

N87-15935# Joint Publications Research Service, Arlington, Va.
DEVELOPMENTS IN STOL AIRCRAFT REPORTED
In its Japan report: Science and Technology (JPRS-JST-87-001) p 1-3 7 Jan. 1987 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Jul. 1986 p 1-2
Avail: NTIS HC A06/MF A01

Wind tunnel tests for the Asuka were performed by using a transonic wind tunnel 2 x 2 m from late May to early June. The main purposes of the tests are as follows: to obtain basic aerodynamic data for expanding the flight area to the high-speed side at flight experiments on the Asuka; and to establish technologies necessary for performing tests on a power model in a transonic wind tunnel. B.G.

N87-15941*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPARISON OF THEORETICAL AND FLIGHT-MEASURED LOCAL FLOW AERODYNAMICS FOR A LOW-ASPECT-RATIO FIN
J. BLAIR JOHNSON and DORAL R. SANDLIN (California Polytechnic State Univ., San Luis Obispo) Dec. 1986 21 p
(Contract NCC-4-1)
(NASA-TM-86806; H-1336; NAS 1.15:86806) Avail: NTIS HC A02/MF A01 CSCL 01A

Flight test and theoretical aerodynamic data were obtained for a flight test fixture mounted on the underside of an F-104G aircraft. The theoretical data were generated using two codes: a two-dimensional transonic code called code H, and a three-dimensional subsonic and supersonic code called wing-body. Pressure distributions generated by the codes for the flight test fixture, as well as compared with the flight-measured data. The two-dimensional code pressure distributions compared well except at the minimum pressure point and the trailing edge. Shock locations compared well except at high transonic speeds. However, the two-dimensional code did not adequately predict the displacement thickness of the flight test fixture. The three-dimensional code pressure distributions compared well except at the trailing edge of the flight test fixture. Author

N87-15942# Air Force Armament Lab., Eglin AFB, Fla.
UNSTEADY 3-DIMENSIONAL EULER EQUATIONS SOLUTIONS ON DYNAMIC BLOCKED GRIDS Final Technical Report, Oct. 1985 - Sep. 1986
DAVE M. BELK Oct. 1986 164 p
(AD-A173977; AFATL-TR-86-74) Avail: NTIS HC A08/MF A01 CSCL 01B

An unsteady implicit Euler equation solution algorithm using finite volume discretization and flux-vector splitting is presented. The effect on time-accuracy of different time step sizes, different approximate factorizations, and formal first-order versus second-order time accuracy is determined by numerical experimentation on a NACA0012 airfoil undergoing pitch oscillations in transonic flow. It is shown that time step sizes corresponding to Courant numbers of 100 or more can produce time-accurate results if flow variables are not rapidly changing. Due to better stability properties, the two-factor method gives better results than the six-factor method. Also, the second-order-time-accurate three point backward time discretization is shown to yield only slight

improvement over the first-order-time-accurate backward Euler time discretization. Methods of obtaining time-accurate Euler solutions on blocked grids are analyzed and verified by comparing multi-block solutions with equivalent one-block solutions. GRA

N87-15943*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, Va.
REMOTE BOUNDARY CONDITIONS FOR UNSTEADY MULTIDIMENSIONAL AERODYNAMIC COMPUTATIONS Final Report
PHILIP L. ROE Nov. 1986 27 p Submitted for publication
(Contract NAS1-18107)
(NASA-CR-178211; ICASE-86-75; NAS 1.26:178211) Avail: NTIS HC A03/MF A01 CSCL 01A

The behavior of gas dynamic flows which are perturbations of a uniform stream in terms of information transfer across artificial (computational) boundaries remote from the source of disturbance are discussed. A set of boundary conditions is derived involving vorticity, entropy, and pressure-velocity relationships derived from bicharacteristic equations. Author

N87-16183# Joint Publications Research Service, Arlington, Va.
NUMERICAL ANALYSIS OF HEAT TRANSFER AT SURFACE OF DELTA WING IN HYPERSONIC AIR STREAM WITH LARGE ANGLE OF ATTACK
N. YE. AFONINA, A. YU. VLASOV, and V. G. GROMOV *In its* USSR Report: Engineering and Equipment p 74 24 Feb. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 5, Sep. - Oct. 1984 p 196-199 Original language document was announced in IAA as A85-16190
Avail: NTIS HC A07/MF A01

An analysis is made of heat transfer for a delta wing with blunt edges and different catalytic properties of the surface in hypersonic flow at attack angles of 40 and 60 deg. Freestream Mach and Reynolds numbers are 24.1 and 0.85 x 10.000, respectively. The study employs a numerical model (using a conservative difference scheme) of the flow of a visious reactive gas in a shock layer at the windward side of blunt elongated bodies. The results indicate that the heterogeneous recombination of atoms has a significant effect on heat transfer. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A87-21073#
BASIC PRINCIPLES FOR PROTECTING AIRCRAFT AGAINST LIGHTNING STRIKES [CONCEPTIONS DE BASE DANS LE DOMAINE DE LA PROTECTION DES AERONEFS CONTRE LE FOUDROIEMENT]
J. TAILLET (ONERA, Chatillon-sous-Bagneux, France) and P. MARTINEZ (Toulouse, Centre d'Essais Aeronautique, France) (Colloque International sur la Securite Aerienne, 2nd, Toulouse, France, Nov. 17-20, 1986) ONERA, TP, no. 1986-174, 1986, 15 p. In French. refs
(ONERA, TP NO. 1986-174)

Ideal and actual techniques for protecting modern aircraft from the hazards of lightning strikes are summarized, with emphasis on methods for offsetting the resistivity of composite materials and the sensitivity of electronic avionics. Planning for lightning protection is described in terms of direct effects, indirect effects (parasitic electromagnetism) and identifying countermeasures for each type of effect for each type of system or component. Methods for analyzing coupling effects are discussed, and national and international trends toward standardization of lightning protection techniques are discussed. M.S.K.

A87-21076#
THE CHARACTERIZATION OF LIGHTNING - A STEP TOWARD BETTER PROTECTION OF AIRCRAFT AGAINST LIGHTNING [LA CARACTERISATION DE LA FOUDRE - UNE ETAPE VERS UNE MEILLEURE PROTECTION DES AERONEFS CONTRE LE FOUDROIEMENT]
J. TAILLET (ONERA, Chatillon-sous-Bagneux, France) and P. MARTINEZ (Toulouse, Centre d'Essais Aeronautique, France) (Colloque International sur la Securite Aerienne, 2nd, Toulouse, France, Nov. 17-20, 1986) ONERA, TP, no. 1986-177, 1986, 11 p. In French. refs
(ONERA, TP NO. 1986-177)

Ground-based and aircraft-based investigations into the characteristics of lighting and the results of the studies are summarized. Experiments are described which featured rockets trailing wires to trigger lightning strikes and guide their stroke, as well as monitoring the associated electrical field. The types of data collected and configurations of instrumented aircraft flown by U.S. and French agencies are detailed. It has thus far been determined that lightning carries currents ranging from 200-400 kA/microsec, that the pulses encountered in flight are discontinuous, and that low-altitude cloud-ground strikes are the most hazardous for aircraft. M.S.K.

A87-22221
THE MENACING MICROBURST
GLENN ZORPETTE IEEE Spectrum (ISSN 0018-9235), vol. 23, Nov. 1986, p. 50-56.

Since 1970, seven crashes attributable to windhsear have killed 575 passengers in the U.S., thereby constituting the largest single source of fatalities; nearly all of these crashes have been linked to microburst phenomena encountered during takeoff runs or landing approaches. Attention is presently given to how effective detection of microbursts can be accomplished by means of Doppler radar. Findings from a meteorological study conducted at Stapleton airport in Denver, CO have led to the differentiation between 'dry' and 'wet' microbursts, the latter being identifiable through its association with rain. It is noted that while Doppler radars are very effective microburst detectors, they remain very expensive solutions for the problem; efforts are accordingly underway to develop cockpit-based warning detectors. O.C.

A87-22222
'GOLD-PLATED' DESIGN
JOHN VOELCKER IEEE Spectrum (ISSN 0018-9235), vol. 23, Nov. 1986, p. 56-64, 66.

State-of-the-art airliners are able to withstand forces during flight emergencies that are far in excess of design levels through the systematic application of high redundancy design criteria by manufacturers. This results in failure rates of less than one in a billion for structures and system components. A typical design methodology used involves the determination of the worst possible effect of every type of failure in each component or subsystem. Multiply redundant systems are also used to minimize the probability of failure during emergencies. A tabulation is presented of recommendations made by the U.S. National Research Council in 1980 to improve FAA airworthiness certification procedures, together with a cut-away of the state-of-the-art 767 airliner which illustrates vehicle complexity. O.C.

A87-22224
HERO OR SCAPEGOAT?
MARK A. FISCHETTI IEEE Spectrum (ISSN 0018-9235), vol. 23, Nov. 1986, p. 75-77.

An airline pilot's ability to meet his responsibilities depends on training and on such imponderables as his treatment by management and his relationships with the copilot and flight engineer. A pilots' survey has identified dissatisfaction with bad flight scheduling and excessive working hours, as well as pressure from managers to overlook maintenance infractions (primarily at smaller airlines). It is noted, more generally, that the expansion in the number of airlines and their flights since the beginning of deregulation in 1978 has led to the hiring of a large number of

younger, less experienced pilots who now accept responsibilities formerly reserved for those with 10-20 years of commercial flight experience. O.C.

A87-22366*# Grumman Aerospace Corp., Bethpage, N.Y.
PARTICLE TRAJECTORY COMPUTER PROGRAM FOR ICING ANALYSIS OF AXISYMMETRIC BODIES - A PROGRESS REPORT
DIMITRIOS G. MALTEZOS (New York, State University, Farmingdale), CHARLES OSONITSCH (Grumman Aerospace Corp., Bethpage, NY), ROBERT J. SHAW (NASA, Lewis Research Center, Cleveland, OH), and ARTHUR KAERCHER (Grumman Data Systems, Bethpage, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p.
(AIAA PAPER 87-0027)

Aircraft exposed to an atmospheric icing environment can accumulate ice, resulting in a sharp increase in drag, a reduction in lift, control surface fouling, and engine damage all of which result in a hazardous flight situation. NASA Lewis Research Center (LeRC) has conducted a program to examine, with the aid of high-speed computer codes, how the trajectories of particles contribute to the ice accumulation on airfoils and engine inlets. For this effort, a computer code was developed to calculate icing particle trajectories and impingement limits for axisymmetric inlets. The original research-oriented NASA code was upgraded and modified to meet the requirements of the design engineer. The improved code is capable of performing trajectory calculations for any atmospheric conditions and droplet sizes. It can handle single droplets or a distribution of various droplet sizes. The four programs that comprise the code are described and the results of a test case using flight conditions for a Fokker F100 icing tunnel test are presented. Author

A87-22464*# Massachusetts Inst. of Tech., Cambridge.
IN-FLIGHT MEASUREMENT OF ICE GROWTH ON AN AIRFOIL USING AN ARRAY OF ULTRASONIC TRANSDUCERS
R. JOHN HANSMAN, JR., MARK S. KIRBY (MIT, Cambridge, MA), ROBERT C. MCKNIGHT (NASA, Lewis Research Center, Cleveland, OH), and ROBERT L. HUMES (Calspan Corp., Arnold Air Force Station, TN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. FAA-supported research. refs
(Contract NGL-22-009-640; NAG3-666)
(AIAA PAPER 87-0178)

Results from three research flights to obtain in-flight ultrasonic pulse-echo measurements of airfoil ice thickness as a function of time using an array of eight ultrasonic transducers mounted flush with the leading edge of the airfoil are presented. The accuracy of the thickness measurements is found to be within 0.5 mm of mechanical and stereophotograph measurements of the ice accretion. The ultrasonic measurements demonstrate that the ice growth rate typically varies during the flight, with variations in the ice growth rate for dry ice growth being primarily due to fluctuations in the cloud liquid water content. Discrepancies between experimental results and results predicted by an analytic icing code underline the need for a better understanding of the physics of wet ice growth. R.R.

A87-22465#
DETECTION AND MEASUREMENT OF ICE ACCRETION ON A PROFILE BY AN ULTRASONIC METHOD
A. A. DEOM and J. C GARNIER (ONERA, Chatillon-sous-Bagneux, France) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p.
(AIAA PAPER 87-0179)

The use of ultrasonic sensors for detecting and measuring ice accretion is described. The ice sensor is composed of a piezoelectric tranducer acoustically bonded to a profile through an interface bulk material used as an acoustic delay. The transducer, which is excited by an electrical signal, generates an ultrasonic wavefront that produces an echo on the reflecting surfaces. The icing condition detection and ice thickness measurement sensors were laboratory tested in icing wind tunnel facilities. The testing reveals that the detection sensor performs well in the temperature range -10 to -30 C, and ice accretion thickness measurements lower than 0.1 mm and up to 20 mm were recorded. I.F.

A87-22567#
WEATHER HAZARDS TRAINING FOR UNITED STATES AIR FORCE (USAF) FLIGHT OPERATIONS
DAVID S. LADWIG (USAF, Air Weather Service, Scott AFB, IL) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 4 p.
(AIAA PAPER 87-0333)

The USAF is strongly concerned with weather hazards affecting flight operations. Training in weather-hazard awareness begins during the initial orientation for every job specially associated with flight operations and is conducted by Air Training Command. Air Weather Service continues weather-hazards training throughout each person's career through the use of follow-on refresher courses and training classes. Each job specialty receives weather-hazard training as it impacts flight operations in its particular area of responsibility, whether it be flying the aircraft or controlling the airspace in which it flies. This paper reviews the USAF approach to weather-hazards training in the job areas directly involved with flight operations. Author

A87-22568#
SIMULATOR TRAINING (RETRAINING) OF AIRCREWS WITH EMPHASIS ON HAZARDOUS WEATHER
CREIGHTON W. PENDARVIS (SimuFlite Training International, Dallas, TX) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p.
(AIAA PAPER 87-0337)

A discussion is presented of the primary considerations in the simulator-based retraining of commercial aircraft crew members in order to enhance their performance in such hazardous flight conditions as the microburst windshear phenomenon. A clear correlation is noted between amount of crew training received and accident probability, as well as between pilot error and the clear majority of commercial aircraft accidents; attention is given to the negotiation of flight through a microburst by three different aircrews. O.C.

A87-22635#
WEATHER AND SYSTEM DELAYS
JOHN F. BLASIC (U.S. National Weather Service, Silver Spring, MD) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0442)

The effects of weather on air traffic are discussed and various examples of air traffic delays caused by weather are presented. Various traffic management techniques such as the severe weather avoidance procedure and quota flow are described. National Weather Service and FAA policies aimed at improving weather forecasting in order to make the national airspace system more efficient and safe are examined. I.F.

A87-22747#
AN ANALYSIS OF THE DELTA 191 WINDSHEAR ACCIDENT
JEFFREY L. GORNEY (National Transportation Safety Board, Washington, DC) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 5 p.
(AIAA PAPER 87-0626)

The crash of a Delta Air Lines L-1011 at the Dallas-Ft. Worth International Airport on August 2, 1985, was another in a string of accidents that the National Transportation Safety Board has attributed to a microburst windshear. The extensive number of flight parameters monitored on the airplane's digital flight data recorder (DFDR) allowed investigators to reconstruct the flightpath winds more accurately than had previously been possible. The reconstruction of the windfield disclosed that the L-1011 penetrated three powerful vortices on the final approach to runway 17L. This paper details the significance of the rapidly shifting winds on the performance and operation of the accident aircraft. In addition,

some of the current industry efforts to increase awareness and recognition of the microburst windshear hazard will be discussed.
Author

N87-15192# National Interagency Coordination Group.
INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY. TECHNICAL PAPERS: THE KEY TO LIGHTNING TECHNOLOGY, HELD IN ORLANDO, FLORIDA ON 26-28 JUNE 1984
Jun. 1984 488 p Conference held in Orlando, Fla., 26-28 Jun. 1984
(AD-A169867) Avail: NTIS HC A21/MF A01 CSCL 01E

The proceedings of the conference are presented. Some titles of the papers presented are: Triggered lightning and corona; Lightning locators; Detection and protection; Indirect effects on systems; Ground systems protections; and Aircraft systems. Some other titles are: Lightning characterization; Thunderstorm studies; Fuel ignition hazards; Lightning stroke measurement; Impulse generators and measurements; Charging mechanisms; and Aircraft and aerospace testing. E.R.

N87-15193# RMS Technologies, Inc., Trevose, Pa.
SEAT EXPERIMENT RESULTS OF FULL-SCALE TRANSPORT AIRCRAFT CONTROLLED IMPACT DEMONSTRATION Final Report, Jan. - Jul. 1985
MARK R. CANNON and RICHARD E. ZIMMERMANN Jul. 1986 261 p Prepared in cooperation with Simula, Inc., Phoenix, Ariz.
(Contract DTFA03-81-C-0040)
(AD-A172245; TR-85413; DOT/FAA/CT-85/25) Avail: NTIS HC A12/MF A01 CSCL 01C

This report describes the results of the Federal Aviation Administration (FAA) seat experiments tested in the joint FAA/NASA Controlled Impact Demonstration (CID). Twenty-three seats were placed on the test aircraft. Thirteen seats were modifications of existing transport seats which were designed structurally to improve their crashworthiness. The remaining experiments were unmodified standard seats which included seven light and heavy-weight forward-facing seats, two aft-facing seats, and one flight attendant seat. Three additional seat experiments were placed onboard the test aircraft: two by NASA, and one by a private contractor. Onboard instrumentation was placed at specific locations to obtain data pertaining to airframe structural loads and seat/occupant response. Accelerometers were attached to the airframe and floor structure, the seat experiments, and the anthropomorphic dummies occupying the seats. The data base resulting from the test was intended for validating crash prediction models and occupant/seat dynamic simulation models. GRA

N87-15194# Federal Aviation Administration, Washington, D.C. Office of Flight Operations.
TASK FORCE ON EMERGENCY EVACUATION OF TRANSPORT AIRPLANES. VOLUME 2: SUPPORTING DOCUMENTATION Final Report
Jul. 1986 474 p
(AD-A172256; DOT/FAA/VS-86-1-VOL-2) Avail: NTIS HC A20/MF A01 CSCL 01B

This is volume 2 of two volumes that report on the study of the emergency evacuation of transport airplanes that was sponsored by the Federal Aviation Administration (FAA). The study included the Public Technical Conference held by the FAA in September 1985 and the public meetings of the three technical working groups that were formed during the conference as part of a task force effort to coordinate the program. The working groups are: Design and Certification, Training and Operations, and Maintenance and Reliability. Contents: List of hearings, conferences, and Meetings--Places and Dates; Federal Register Announcement of Public Technical Conference; Attendance List for Public Technical Conference; Summary of Congressional Hearing and Public Technical Conference; Formal Presentations of the Public Technical Conference; Working Group Interim Reports and Background Information. GRA

N87-15195# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 7 OF 1985 ACCIDENTS
2 Jul. 1986 402 p
(PB86-916921; NTSB-AAB-86-21) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01B

Aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during calendar year 1985 are given. Approximately 200 general aviation and air carrier accidents contained in the publication represent a random selection. GRA

N87-15196# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 6 OF 1985 ACCIDENTS
15 Jul. 1986 390 p
(PB86-916920; NTSB-AAB-86-20) Avail: NTIS HC A17/MF A01; also avialbble on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during calendar year 1985 are given. Approximately 200 general aviation and air carrier accidents contained in the publication represent a random selection. GRA

N87-15948# Naval Weapons Center, China Lake, Calif.
IN-FLIGHT EJECTION SEAT TEST USING THE AIRCREW GLIDING ESCAPE SYSTEM (AGES) PARACHUTE Final Report, Oct. 1984 - Aug. 1986
MANLEY C. BUTLER, JR. Sep. 1986 80 p
(AD-A172987; NWC-TP-6741) Avail: NTIS HC A05/MF A01 CSCL 01C

The objective of the Aircrew Gliding Escape System (AGES) Program is to develop a ram-air-inflated, gliding parachute wing for use in Navy aircrew escape systems. This report describes an in-flight ejection test conducted at the Naval Weapons Center on 23 October 1984 using the AGES parachute canopy in a Stencel SIIIS-3-ER ejection seat. The test was initiated at 500 knots equivalent airspeed (KEAS) at 5000 feet AGL (7500 feet MSL) from the rear seat of the Center's YF-4 aircraft. The riser loads on the dummy were well within acceptable limits, and no damage occurred to the parachute or the seat system (which was recovered by a separate parachute). (U) This report contains complete documentation of the test setup for the seat and parachute. In addition, copies of the test plan, abort criteria, and checklists are included. GRA

N87-15950# General Dynamics/Fort Worth, Tex.
EVALUATION OF IMPROVED ENGINE COMPARTMENT OVERHEAT DETECTION TECHNIQUES Final Technical Report, Aug. 1985 - Aug. 1986
R. C. FOSTER, C. BARKER, D. W. GOODWIN, V. ROWE, and C. E. PORCHER Aug. 1986 177 p
(Contract F33615-85-C-2548)
(AD-A173960; FZM-7415; AFWAL-TR-86-2060) Avail: NTIS HC A09/MF A01 CSCL 21E

A study was conducted to evaluate the feasibility of utilizing infrared (IR) sensor technology to detect leaks from failed aircraft bleed ducts. Improved overheat detection system requirements were defined and detection concepts were formulated based on these requirements. An IR detection concept was shown to exhibit potential for improvement over other concepts formulated and existing cable type detection elements. A nacelle/bleed duct simulator was designed and fabricated in order to conduct tests of IR detection concepts. Radiation detection instrumentation was designed for utilizing the IR instrumentation and a Systron-Donner element to detect simulated bleed leaks at three different flight conditions. The test data was analyzed to evaluate the feasibility of IR detection techniques and the relative performance of the IR

techniques with respect to cable-type elements was determined.
GRA

N87-15951# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS. BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 11, 1985 ACCIDENTS
5 Sep. 1986 423 p
(PB86-916925; NTSB-AAB-86-26) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent HC $185.00/year, all others write for quote CSCL 01C

Selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985 are given. Approximately 200 General Aviation and Air Carrier accidents represent a random selection. The facts, conditions, circumstances and probable cause(s) for each accident are given.
GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A87-19997
GPS ENHANCEMENTS FOR AIRCRAFT
L. F. WIEDERHOLT (Intermetrics, Inc., Cambridge, MA) and D. KLEIN Avionics (ISSN 0273-7639), vol. 10, Sept. 1986, p. 18, 20, 22, 23.

The uses of GPS for rendezvous, sensor calibration, INS update and alignment, navigation, training and evaluation, and identification of friend or foe are described. The benefits GPS can provide to rendezvous, instrument calibration, and INS performance are discussed. Consideration is given to acceleration, velocity, altitude, attitude, time, and initialization aidings. The applications of GPS to training pilots and crews and for evaluating instruments are studied. Passive and active forms of friend or foe identification are examined. I.F.

A87-22220
A MATTER OF MARGINS
TEKLA S. PERRY and PAUL WALLICH IEEE Spectrum (ISSN 0018-9235), vol. 23, Nov. 1986, p. 38-50.

An evaluation is made of the safety-related aspects of the 23,000-element U.S. ATC system, which encompasses radio communications, radar operations and extensive computer processing of position and direction data. System component breakdowns are noted to be often due to the obsolescence of the radio and radar equipment employed; some of the radars in the system date to World War II and use vacuum tube electronics. Computers that become overloaded with data must discard some information in order to continue operating, notwithstanding the potential usefulness of this data to ATC controllers. Attention is given to equipment faults, the failures they characteristically cause, and the real-time and longer term solutions possible for them.
O.C.

A87-23068
ATMOS: REAL-TIME SIMULATION OF MAN/MACHINE-INTERACTION IN AIR TRAFFIC MANAGEMENT (ATMOS - AIR TRAFFIC MANAGEMENT AND OPERATIONS SIMULATOR)
JOSEF THOMAS (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 565-570.

The Air Traffic Management and Operations Simulator (ATMOS) is a real-time research and development testbed integrating several stand-alone experimental facilities as required by specific investigations. ATMOS encompasses airborne and ground-based components that are linked by a central computer array and an ETHERNET local area network. In its most recent application, ATMOS hosted an extensive experimental feasibility study for a computer aid aiming at the efficient handling of inbound traffic; ATMOS set up the full scenario for the evaluation, including various traffic samples, hardware and software interfaces for communication with the system tested, and all data required for quick-look and off-line analysis. O.C.

N87-15197*# Boeing Commercial Airplane Co., Seattle, Wash.
AN EVALUATION OF DESCENT STRATEGIES FOR TNAV-EQUIPPED AIRCRAFT IN AN ADVANCED METERING ENVIRONMENT
K. H. IZUMI, R. W. SCHWAB, J. L. GROCE, and M. A. COOTE 1986 80 p
(Contract NAS1-17635)
(NASA-CR-178093; NAS 1.26:178093; D6-53153) Avail: NTIS HC A05/MF A01 CSCL 17G

Investigated were the effects on system throughput and fleet fuel usage of arrival aircraft utilizing three 4D RNAV descent strategies (cost optimal, clean-idle Mach/CAS and constant descent angle Mach/CAS), both individually and in combination, in an advanced air traffic control metering environment. Results are presented for all mixtures of arrival traffic consisting of three Boeing commercial jet types and for all combinations of the three descent strategies for a typical en route metering airport arrival distribution. Author

N87-15198# Federal Aviation Administration, Washington, D.C. ATCRBS Analysis Team.
AIR TRAFFIC CONTROL RADAR BEACON SYSTEM TRANSPONDER PERFORMANCE STUDY AND ANALYSIS. VOL. 1: TRANSPONDER TEST METHODOLOGY RESULTS, ANALYSIS AND RECOMMENDATIONS Final Report
Sep. 1986 43 p
(DOT/FAA/FS-86/1.1-VOL-1) Avail: NTIS HC A03/MF A01

The description and results of the Air Traffic Control Radar Beacon System (ATCRBS) Transponder Study and Analysis are given. This study represents a two year effort consisting of testing, data collection, and analysis of air carrier, military, and general aviation transponder performance. The ATCRBS Analyis Team developed a comprehensive test plan which included a validation flight test program, an evaluation of transponder maintenance and calibration programs, and a detailed analysis of general aviation transponder performance. The study was concentrated in the Atlanta, Georgia area. However, data was collected from many parts of the country. The Mobile Transponder Performance Analyzer (MTPA), developed by the FAA Technical Center, was dispatched to field locations in order to support the data collection and analysis tasks. This effort resulted in identifying a trend of problems associated with the general aviation transponder. Author

N87-15199# Department of the Army, Washington, D. C.
AIRCRAFT COLLISION WARNING SYSTEM Patent Application
RAYMOND W. CONRAD, inventor (to Army) 15 Aug. 1986 13 p
(AD-D012463; US-PATENT-APPL-SN-896788) Avail: NTIS HC A02/MF A01 CSCL 01D

An aircraft collision warning system is described in which a low power pulsed laser system projects narrow bandwidth radiation into 4 pi steradians around an aircraft and a matched, narrow bandwidth receiver system, with a 4 pi steradian field-of-view which detects such radiation emitted from another aircraft within range of the receiver and activates appropriate warning. GRA

N87-15200# General Accounting Office, Washington, D. C. Information Management and Technology Div.
AIR TRAFFIC CONTROL: FAA'S (FEDERAL AVIATION ADMINISTRATION'S) ADVANCED AUTOMATION SYSTEM ACQUISITION STRATEGY IS RISKY
Jul. 1986 41 p
(PB86-231743; GAO/IMTEC-86-24; B-206887) Avail: NTIS HC A03/MF A01 CSCL 17G

Evaluation shows that FAA's current acquisition strategy for the Advanced Automation System does not adequately mitigate technical risks and does not provide for suitable operational simulation of the advanced automation features before the Department of Transportation commits to the multi-billion-dollar contract for full production. In addition, it is shown that the Advanced Automation System, as currently planned, may not be economically justified. FAA's congressionally mandated benefit/cost analysis, recently initiated and scheduled for completion late next year, should provide more information on the issue. GRA

N87-15953# Mitre Corp., McLean, Va. Metrek Div.
A PROPOSED SINGLE CRITERION FOR IFR (INSTRUMENT FLIGHT RULES) APPROACHES TO CONVERGING RUNWAYS
WILLIAM E. WEISS Jul. 1986 81 p
(Contract DTFA01-84-C-0001)
(AD-A171844; MTR-86W17; FAA-DL5-86-2) Avail: NTIS HC A05/MF A01 CSCL 01E

This document discusses three criteria currently under consideration for operating independent approaches to converging runways under Instrument Flight Rules. These criteria include the Worst-Case Boundaries, developed for the Federal Aviation Administration (FAA) by The MITRE Corporation; the application of nonoverlapping Terminal Instrument Procedures (TERPS) obstacle clearance surfaces to provide protected airspace, developed by the FAA's Air Traffic Operations Service; and Tower-Applied Visual Separation on Missed Approach, currently used in Chicago. A Single Criterion is then proposed which combines elements of the TERPS Criterion and the Worst-Case analysis. This criterion provides explicit blunder protection and its dimensions are functions of measurable navigation performance parameters. However, the decision heights obtained using the Single Criterion are generally higher than those obtained using the TERPS+3 Criterion. This leads to the conclusion that, using the techniques described for the Single Criterion, decision heights lower than those generated by the TERPS+3 Criterion may not be feasible for independent IFR approaches to converging runways. However, the Single Criterion may be useful in the future because it is directly related to aircraft performance on missed approach. Any improvements in navigation and/or aircraft performance can be reflected in this criterion, with a corresponding lowering of decision heights. GRA

N87-15954# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
STUDY OF THE EFFECTS OF VIBRATION ON INERTIAL NAVIGATION SYSTEM ACCURACY M.S. Thesis
DONALD J. KOCIAN Jun. 1986 124 p
(AD-A172420; AFIT/GE/ENG/86J-2) Avail: NTIS HC A06/MF A01 CSCL 17G

This study examines the effects of airframe vibration on the accuracy of a strapdown inertial navigation system. A stochastic model of the system error equations is included, as are two models of airframe vibration. Software subroutines for model implementation in SOFE are included. A representative C-130A flight profile was developed using a flight trajectory generator, PROFGEN. The system errors induced in the inertial navigation by simulating this mission are included as are those caused by vibration. Vibration induced errors were found to be very small and orders of magnitudes smaller than those caused by other error sources. GRA

N87-15956# Arinc Research Corp., Annapolis, Md.
EVALUATION OF ALTERNATIVES FOR ARMY PRECISION LANDING SYSTEM: GROUND GUIDANCE Final Report, 1 Oct. 1985 - 31 Jul. 1986
C. BOYD, J. GRUHLER, and R. LEWSEN Jul. 1986 61 p
(Contract DAEA18-84-C-0127)
(AD-A174093; REPT-2959-01-2-4106) Avail: NTIS HC A04/MF A01 CSCL 17G

This report deals with current and planned aircraft guidance systems as they apply to Army tactical precision landings in the combat environment. Self-contained avionics systems and less sophisticated systems have been evaluated. Ground guidance is defined as a means to safely, efficiently, and rapidly aid in the movement of aircraft from their transition point of landing to a final destination. The study addressed the following four tasks: review army requirements (Ground Guidance) by research of current documentation and by extensive interviews; identify alternative systems through specifications and discussions with government and industrial personnel; evaluate systems by conducting aviator and engineer evaluations; and identify and document best approach for Army use in the tactical environment. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-20378
AN EVALUATION OF THE EFFICIENCY OF DESIGN SOLUTIONS DURING THE DESIGN OF AIRSHIPS [OTSENKA EFFEKTIVNOSTI KONSTRUKTORSKIKH RESHENII PRI PROEKTIROVANII AEROSTATICHESKIKH LETATEL'NYKH APPARATOV]
E. V. GOLDOBEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 11-14. In Russian.

The methodological aspects of the technical and economical evaluation of airships are examined. In particular, the cost equivalents of an increase in the total annual flight hours are determined. It is shown that the effect of the flight hours per year on the cost characteristics is more pronounced in the case of large airships. V.L.

A87-20525
SUKHOI FITTER
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 31, Sept. 1986, p. 123-128, 130, 131.

The Su-7/17 series of jet aircraft, first flown in the 1950s, still forms the background of Soviet ground attack aircraft, with over 800 upgraded versions still in service. Progressive enhancements of the engine to achieve current thrusts over 20,000 lb and takeoff weights of around 30,000 lb are described. Techniques used to maintain flight stability in introducing variable sweep into the aircraft configuration are discussed, along with the emplacement of various electronic devices in later versions of the aircraft such as the Fitter-C and -D, which were equipped with a nav-air attack sensor and a laser rangefinder, respectively. Finally, a comprehensive cutaway drawing is provided of the structure and equipment of tne Fitter-K, including avionics and ordnance stores. M.S.K.

A87-20799
ON AIRCRAFT FLIGHT PERFORMANCE IN A PERTURBED ATMOSPHERE
L. M. B. C. CAMPOS (Instituto Superior Tecnico, Lisbon, Portugal) Aeronautical Journal (ISSN 0001-9240), vol. 90, Oct. 1986, p. 302-312. refs

A minimum aerodynamic basis is used in the present calculations of the effects on flight mechanics of such atmospheric disturbances as wind gusts and shears, wakes, and downflows. It

is demonstrated that the relative lift change, due to wind, or shear, or both, coincides with the disturbance intensity, G (defined as the instantaneous vertical acceleration, measured in g's) that an aircraft will experience as a result of atmospheric disturbances, assuming a constant velocity and attitude. O.C.

A87-20993
DERIVATION OF EXTERNAL STORE VIBRATION TEST SPECTRA FROM FLIGHT DATA
WILLIAM B. ROBERTS (British Aerospace, PLC, Hatfield, England) (Institute of Environmental Sciences, Annual Technical Meeting, 32nd, Dallas, TX, May 1986) Journal of Environmental Sciences (ISSN 0022-0906), vol. 29, Sept.-Oct. 1986, p. 22-25. refs

Attention is given to the acquisition and subsequent reduction of vibration data from instrumented air-craft-carried weapon systems. In-flight measured data from externally carried stores flown on several different host aircraft are provided and a comparison is made with standard vibration test levels. It is shown that a vibration plus climatic environments qualification test can be designed to satisfy the total aircraft carried-life vibration requirement of a weapon system. K.K.

A87-21014#
FUNDAMENTALS OF FIGHTER AIRCRAFT DESIGN - ENGINE INTAKE AND AFTERBODY
J. LEYNAERT (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Special Course No. 2 on Fundamentals of Fighter Aircraft Design, Brussels, Belgium, Feb. 17-21, 1986 and Athens, Greece, Feb. 24, 25, 1986, and Ankara, Turkey, Feb. 27, 28, 1986) ONERA, TP, no. 1986-83, 1986, 47 p. refs
(ONERA, TP NO. 1986-83)

Basic conditions, study parameters, and various solutions of fighter intake and afterbody (except VTOL) are reviewed. Airframe integration and intake adaptation to the flight Mach number are discussed. The following topics of intake flow are analyzed: buzz phenomenon, internal bleed flow, high incidence, low speed, mean flow, distortion index, and unsteady distortion. The afterbody discussion covers variable geometry, thrust vectoring, and reverse. Wind-tunnel test techniques are also commented on. Author

A87-21039#
THE USE OF ADVANCED AERODYNAMIC MODELS IN THE AEROELASTIC COMPUTATIONS OF HELICOPTER ROTORS
R. DAT and C. T. TRAN (ONERA, Chatillon-sous-Bagneux, France) (DGLR, European Rotorcraft and Powered Lift Aircraft Forum, 12th, Garmisch-Partenkirchen, West Germany, Sept. 22-25, 1986) ONERA, TP, no. 1986-120, 1986, 16 p. refs
(ONERA, TP NO. 1986-120)

The development of theoretical and semiempirical methods enables one to take into account three-dimensional, transonic and unsteady stall effects for a prescribed blade motion, but as the dynamics equations of the coupled aeromechanical system cannot be formulated in a simple manner, the calculations of periodic responses and stability analysis are difficult to perform. A procedure of solution by iteration is discussed for the case of periodic responses. Author

A87-21252#
EXPERTS DISSECT MIG-29
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1986, p. 12-15.

The potential capabilities of the newly revealed Soviet fighter-aircraft model, MiG-29 (called Fulcrum by NATO), as derived by experts on the basis of the ground and flight photographs, are analyzed. It is considered that the MiG-29 design has borrowed from the best of the F-14 and F-15, but has some features that helped to eliminate the shortcomings of these aircraft. The possible deficiencies of the aircraft may be a limited pilot visibility, and the use of extensive internal ducting that may lead to inefficient pressure recovery. However, the MiG-29 is considered to be innovative, and if it can be produced in quantity and with good avionics and weapons systems, it may present a challenge to the best fighters of the West. I.S.

A87-21276#
BOEING 747 CRASH ACCIDENT - A THEORETICAL CONSIDERATION ON THE VARIATION OF THE INTERNAL PRESSURE
HIROICHI OHIRA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 59, June 1986, p. 249-255. In Japanese, with abstract in English.

The Boeing 747 accident which occurred in Japan on Aug. 12, 1985, is studied. Under the assumption that the pressure dome broke first, the variation of the pressure in the afterbody is analyzed theoretically. The cases of the pressure relief opening and not opening are both examined. It is shown that the net pressure applied to the fin never exceeded 1 atm, and that the fracture of the fire wall occurred last. The fracture was caused by collapse of the vertical tail. Various phenomena such as the 'white mist' and the drop of oxygen masks can be predicted. C.D.

A87-21277#
BOEING 747 CRASH ACCIDENT - A THEORETICAL CONSIDERATION ON THE FRACTURES OF THE STRUCTURE
HIROICHI OHIRA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 59, June 1986, p. 257-263. In Japanese, with abstract in English.

The successive structural fractures which occurred in the Boeing 747 accident of 1985 are theoretically studied. The collapse mechanism of the fin is explained. It is likely that the fin, when falling down, hit the tail cone, causing the fracture of the fire wall. The 'bang' seems to have been caused by this hitting. The pressure dome apparently broke a few seconds earlier than heretofore suggested. A general hypothesis about what happened to the aircraft is given. C.D.

A87-21449
MIG-29 - LAST OF THE HOT RED FIGHTERS?
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 41, Oct. 1986, p. 1119-1122.

A wide-ranging evaluative discussion is presented concerning the design features and comparative performance of the MiG-29 'Fulcrum' air superiority fighter, in view of both its immediate Soviet predecessors and the Western aircraft that are its prospective adversaries, such as the F-15 and F-18. It is noted that fighters of the complexity exhibited by the MiG-29 will be produced by the USSR in substantially smaller numbers than their simpler predecessors. A large radar dish diameter that indicates look-down/shoot-down capabilities is a prominent feature of the design. O.C.

A87-21450
MIKOYAN FULCRUM
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 31, Nov. 1986, p. 237-240, 258.

A preliminary evaluation is made of the design features and inferred performance capabilities of the MiG-29 'Fulcrum' air-superiority Soviet fighter, in light of observations conducted during a visit of several of these aircraft to Finland. Significant advancements over Soviet design practices are noted in the use of low-sfc turbofan engines, fuselage-blended wing strakes, and high-visibility cockpit bubble. A new medium-range guided missile, the AA-10, has been developed for incorporation by the MiG-29; a 23-mm rotary cannon is also used. O.C.

A87-22333
PREDICTION OF FATIGUE LIFE FOR AIRCRAFT LOADING AND IMPORTANCE OF THE RELATIVE METHOD IN THE CASE OF LOCAL STRAIN APPROACH
ALFRED BUCH (Technion - Israel Institute of Technology, Haifa) Materialpruefung (ISSN 0025-5300), vol. 28, Oct. 1986, p. 315-320. refs

The use of correction factors for improving life prediction until crack initiation is studied. Examples of load programs for upper

and lower aircraft wing surfaces are presented which show that the accuracy and reliability of prediction in the Local Strain Approach is increased if the correction factors are established for similar cases. Good results are obtained for a simple grouping of load cycles as well as for realistic load cycle sequences. C.D.

A87-22365#
MODELLING OF SURFACE BLOWING FROM DISCRETE SLOTS AS A MECHANISM FOR PREVENTING ICE ACCRETION ON AIRCRAFT SURFACES
A. H. TABRIZI (Indiana Institute of Technology, Fort Wayne) and EDWARD G. KESHOCK (Tennessee, University, Knoxville) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0026)

An analysis of a proposed possible anti-icing technique applicable to aircraft surfaces has been studied and is described herein. Air injection at the leading edge of an ice-accreting surface is used to reduce and/or eliminate ice collection by preventing the supercooled water droplets in the atmosphere from impinging on the surface. In this envisioned technique a discrete stream of fluid (air) is injected into the main stream through slots located on the cylinder surface. The modified flow around the surface produces modified droplet trajectories, deflecting the droplets away from the surface. Exact mathematical expressions for the velocities are obtained from potential flow theory. Droplet trajectories are obtained for a variety of surface blowing conditions. It was found that for a given cylinder diameter, free stream velocity, droplet size, and injection, there is an optimum slot location for which the injection has its maximum effect, ie., minimum water collection and subsequent ice accretion. The effect of injection rate as well as the number of slots on the collection efficiency are also investigated. Author

A87-22402*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
CHALLENGES IN MODELING THE X-29A FLIGHT TEST PERFORMANCE
JOHN W. HICKS (NASA, Flight Research Center, Edwards, CA), JAN KANIA (USAF, Flight Test Center, Edwards AFB, CA), ROBERT PEARCE, and GLEN MILLS (Grumman Aerospace Corp., Edwards, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0081)

The paper presents the methods, instrumentation, and difficulties associated with drag measurement of the X-29A aircraft. The initial performance objective of the X-29A program emphasized drag polar shapes rather than absolute drag levels. Priorities during the flight envelope expansion restricted the evaluation of aircraft performance. Changes in aircraft configuration, uncertainties in angle-of-attack calibration, and limitations in instrumentation complicated the analysis. Limited engine instrumentation with uncertainties in overall in-flight thrust accuracy made it difficult to obtain reliable values of coefficient of parasite drag. The aircraft was incapable of tracking the automatic camber control trim schedule for optimum wing flaperon deflection during typical dynamic performance maneuvers; this has also complicated the drag polar shape modeling. The X-29A was far enough off the schedule that the developed trim drag correction procedure has proven inadequate. Despite these obstacles, good drag polar shapes have been developed throughout the flight envelope. Preliminary flight results have compared well with wind tunnel predictions. A more comprehensive analysis must be done to complete the performance models. The detailed flight performance program with a calibrated engine will benefit from the experience gained during this preliminary performance phase. Author

A87-22403*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
FLIGHT TEST TECHNIQUES FOR THE X-29A AIRCRAFT
JOHN W. HICKS, JAMES M. COOPER, JR., and WALTER J. SEFIC (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs (Contract L)
(AIAA PAPER 87-0082)

The X-29A advanced technology demonstrator is a single-seat, single-engine aircraft with a forward-swept wing. The aircraft incorporates many advanced technologies being considered for this country's next generation of aircraft. This unusual aircraft configuration, which had never been flown before, required a precise approach to flight envelope expansion. This paper describes the real-time analysis methods and flight test techniques used during the envelope expansion of the X-29A aircraft, including new and innovative techniques that provided for a safe, efficient envelope expansion. The use of integrated test blocks in the expansion program and in the overall flight test approach is discussed. Author

A87-22404*# Texas A&M Univ., College Station.
FLOW ENERGIZER FLIGHT TESTS ON A LIGHT TWIN AIRCRAFT
D. T. WARD, A. A. PRADHAN, and R. S. BINFORD (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p.
(Contract NAG1-344)
(AIAA PAPER 87-0083)

Experiments were conducted to explore the use of flow energizers (i.e., horizontally mounted vortex generators), using a special instrumentation subsystem installed on a light twin aircraft. The data, collected for energizer configurations with convergence ratios of 1.2, 1.5, and 1.7, included measurements of pressure on the wing surface, velocity components in the wake of the energizer, and forces on the flow energizer itself. Surface pressure data showed that flow energizer effects are highly localized. The energizer with the smallest convergence ratio tested produced an energizer lift/drag ratio about 75 percent lower that that of the other two configurations. For highly swept planforms, cambered energizers with overlaps of the order of 12-15 percent of the local chord provide the best results. I.S.

A87-22405#
THE APPLICATION OF SUB-BOUNDARY LAYER VORTEX GENERATORS TO REDUCE CANOPY 'MACH RUMBLE' INTERIOR NOISE ON THE GULFSTREAM III
ALVIN E. HOLMES, PAUL K. HICKEY, WILLIAM R. MURPHY, and DAVID A. HILTON (Gulfstream Aerospace Corp., Savannah, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0084)

A low frequency noise has been observed in the cabin of the Gulfstream III corporate aircraft at high Mach number cruise conditions. The noise, known as 'Mach rumble', is variable in intensity and tends to increase with increasing Mach number. Acoustic measurements had suggested that an externally mounted VHF blade antenna was in some way interrelated. Investigation of available data indicated that a small region of shock induced flow separation exists at high Mach numbers on the canopy. Furthermore, it was hypothesized that the antenna is excited by a von Karman vortex street that is shed from the canopy shock wave. A significant reduction in interior noise was realized through application of very low profile, 1/8 in. high, Sub-Boundary layer Vortex Generators (SBVG's). Acting much like conventional vortex generators, SBVG's effectively delay separation as well as break up the vortex street, eliminating two major noise sources. Thus a substantial cabin noise reduction (1.5 to 4.5 dBA) is obtained by the easy retrofit installation of external SBVG's weighing only a fraction of an ounce. Author

A87-22437#
DEVELOPMENT OF A ROTATING BLADE FINITE ELEMENT WITH AN APPLICATION TO THE ANALYSIS OF HELICOPTER ROTOR SYSTEMS
PATRICK J. MAGARI and LOUIS A. SHULTZ (Syracuse University, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0141)

A rotating blade finite element with coupled bending, torsion, and axial stretching degrees-of-freedom is derived as well as an associated consistent mass matrix for dynamic applications. Both are validated through comparisons with available experimental and analytical results and include nonuniform highly-twisted rotating blades with no planes of symmetry. Finally, the present element is applied to determine the dynamic characteristics of a multiple-load-path rotor blade of a bearingless rotor; the bearingless rotor is a potential candidate for the U.S. Army's LHX program. It is noted that without the present element, exact analysis of these multiple-load-path bearingless rotors is impossible. K.K.

A87-22441#
A MODEL COMPARISON OF A SUPERSONIC AIRCRAFT MINIMUM TIME-TO-CLIMB PROBLEM
SHAW Y. ONG (Iowa State University of Science of Technology, Ames) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0146)

A minimum time-to-climb problem is formulated as a parameterized optimal control problem and is solved using sequential quadratic programming. Five dynamic models are treated. The five-state model features the usual point-mass equations of motion for flight in a vertical plane. Time is the independent variable, and speed, altitude, flight path angle, range, and mass are the dependent variables. Range is used to replace time as the independent variable for the remaining four models. The last of these is the well-known energy-state approximation with specific energy as the only state variable and speed as the control variable. The primary objective is to compare the solutions for each of the five models with regard to accuracy and computational effort. Numerical results are presented for an early representation of the F-4 fighter aircraft. Author

A87-22488#
A PRELIMINARY DESIGN AND SCREENING PROCESS FOR MISSILE AIRFRAME CONFIGURATIONS
L. H. SCHINDEL (U.S. Navy, Naval Surface Weapons Center, Silver Spring, MD) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0211)

A code for computing aerodynamic coefficients of missiles with noncircular bodies is described. The program is fast, versatile, and easy to use so that it is especially suitable for the preliminary design of missile air frames. Its accuracy is consistent with the requirements of examining many configurations and flight conditions in order to identify promising candidates for development. Author

A87-22523#
WING ROCK GENERATED BY FOREBODY VORTICES
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0268)

An analysis is performed of experimental results showing that wing rock occurs for a tapered wing of aspect ratio 4, provided it is preceded by a long ogive-cylinder body. In spite of the rather large wing span and associated roll damping the wing rock is more violent than for a delta wing with high swept leading edges. This surprising result is found to be caused by the critical flow conditions existing on the slender forebody, allowing the 'moving-wall' effect on boundary layer transition to generate the switching of separation- and vortex-asymmetries needed to produce the observed wing rock. Author

A87-22524#
PREDICTING THE EFFECTS OF AIRCRAFT GEOMETRY ON THE CARRIAGE AND RELEASE OF EXTERNAL STORES
J. A. ROSS (Royal Aircraft Establishment, Bedford, England) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(AIAA PAPER 87-0270)

An empirically based prediction technique for the installed drag of external stores is described, together with recent experimental work to investigate the parameters determining installed drag. The experimental studies have identified guidelines for the realization of configurations having low installed drag. Studies on installed drag are related to similar parametric studies on the factors influencing store release disturbances. It is shown that in some cases features which minimize installed drag also lead to low levels of release disturbance. Finally a brief description is given of work to develop a prediction method for store carriage loads and the effects of external stores on overall stability. Author

A87-22641#
ISOCHRONES FOR MINIMUM TIME HORIZONTAL GLIDING FLIGHT
JENG-SHING CHERN (Chung Shan Intitute of Science and Technology, Lungtan, Republic of China) and LI-YUE LIANG (National Cheng Kung University, Tainan, Republic of China) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0449)

This paper presents the optimal trajectories for the minimum time subsonic gliding flight in a horizontal plane by the application of Pontryagin's maximum principle. The gliding vehicle is assumed to be carried by an airplane which can cruise at a certain low altitude with a certain constant speed. Then at a certain point when the airplane is within the reachable domain of the gliding vehicle from the target to be attacked, the gliding vehicle is released. It then glides to the target by following a minimum time trajectory and the carrier airplane escapes the arena at the same time. For gliding flight in a horizontal plane, there are two constraints to deal with simultaneously. They are the equality constraint to maintain the vehicle in a horizontal flight and the inequality constraint that the lift coefficient must not exceed the maximum lift coefficient of the vehicle. This paper uses the multiple shooting method, the Newton-Raphson method, and the continuation method to find the exact solutions of the optimal trajectories. The problem of minimum time gliding flight in a horizontal plane is completely solved. From the numerical computation results, the isochrones are plotted. Author

A87-22689*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VALIDATION OF AN INTERIOR NOISE PREDICTION MODEL FOR A COMPOSITE CYLINDER
TODD B. BEYER (NASA, Langley Research Center, Hampton, VA) and FERDINAND W. GROSVELD (Bionetics Corp., Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0529)

An acoustic modal analysis has been performed in the cavity of a composite cylinder model of an aircraft fuselage. The filament wound, composite shell is 12 feet long and 5.5 feet in diameter. A one-half-in. thick plywood floor is attached to the shell 69 deg from the vertical centerline through the bottom of the shell. The acoustic modal frequencies were obtained from a sound pressure level and phase survey conducted throughout the interior volume bounded by the floor, endcaps and stiffened shell, while being excited by white noise from a loudspeaker source. The measured acoustic resonance frequencies and mode shapes compare well with analytical predictions from the Propeller Aircraft Interior Noise (PAIN) model. Details of the theory and derivation of the acoustic characteristics have been included. Reverberation time measurements, using the integrated impulse technique, have been performed to determine acoustic loss factors. These measured loss factors have been input to the PAIN program in order to

more accurately predict the space-averaged interior noise of the composite cylinder. Author

A87-22745*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
AIRCRAFT PARAMETER ESTIMATION
KENNETH W. ILIFF (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 27 p. refs
(AIAA PAPER 87-0623)

The aircraft parameter estimation problem is used to illustrate the utility of parameter estimation, which applies to many engineering and scientific fields. Maximum likelihood estimation has been used to extract stability and control derivatives from flight data for many years. This paper presents some of the basic concepts of aircraft parameter estimation and briefly surveys the literature in the field. The maximum likelihood estimator is discussed, and the basic concepts of minimization and estimation are examined for a simple simulated aircraft example. The cost functions that are to be minimized during estimation are defined and discussed. Graphic representations of the cost functions are given to illustrate the minimization process. Finally, the basic concepts are generalized, and estimation from flight data is discussed. Some of the major conclusions for the simulated examples are also developed for the analysis of flight data from the F-14, highly maneuverable aircraft technology (HiMAT), and Space Shuttle vehicles. Author

A87-22823
AUTOMATED OPTIMUM DESIGN OF WING STRUCTURES - A PROBABILISTIC APPROACH
S. S. RAO (Purdue University, West Lafayette, IN) Computers and Structures (ISSN 0045-7949), vol. 24, no. 5, 1986, p. 799-808. refs

The optimization of aircraft wing structures is presented by considering the dynamic stresses developed during landing impact and gust load conditions. The random nature of the sinking speed and the forward velocity at the instant of contact is considered in the calculation of landing stresses. The vertical velocity due to gust is treated as a stochastic process for the computation of gust-induced stresses. The optimum designs of a symmetric double wedge airfoil, based on beam type of analysis, and a supersonic airplane wing, based on finite element analysis, are considered to illustrate the procedure. A graphical procedure is used in the case of the double wedge airfoil, and nonlinear programming techniques are used in the case of the supersonic wing, for finding the optimum solutions. Author

A87-22824
CONNECTING 8000 PSI HYDRAULIC SYSTEMS
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Nov. 1986, p. 8-13.

The 8000-psi hydraulic systems, some of which will use the CTFE fluids, will put new demands on the designs of the fittings and adapters of the system. Methods aimed at minimizing the impact of the increased pressure and the heavier fluid on the connecting elements are considered. Fitting-tubing joints which employ the swaging method (based on the concept that the fitting material is softer than the tubing material) of connection are described. The new joints will weigh less and take up less space, and will be able to use a fire-resistant fluid. Fluid adapters for making connections between the components are being developed; their designs include a mechanical positive lock and will incorporate provisions against port damage due to overtorquing during tubing installation. I.S.

A87-22825
X WING BEGINS FLIGHT TESTING
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Nov. 1986, p. 16-21.

The X-wing is an aircraft capable of flying like a helicopter in a hover flight and like a fixed-wing aircraft in an up-and-away flight. The core of the X-wing is its pneumodynamic system, which provides air supply for all modes of flight. The X-wing structure consists of high-modulus high-strain graphite fiber impregnated with bismaleimide matrix. The blade/wing consists of a hollow sleeve bonded to an I-beam; both the sleeve and the I-beam are bolted to a bearingless titanium hub; they can be twisted mechanically without the need for bearings, providing the stiffness needed in the operation in fixed-wing configuration. Flight tests will concentrate on the conversion from fixed wing to rotary wing, and vice versa. The aircraft will climb to the designated test altitude and will commence conversions at about 200 knots. In several test sequences, rotor rpm will be reduced in increments of 10 percent (and raised back 10 percent) on separate flights; the data will be analyzed prior to going to the next increment. I.S.

A87-22919
GULFSTREAM IV - FLYING THE CORPORATE LEADER
ROBIN BLECH Flight International (ISSN 0015-3710), vol. 130, Nov. 1, 1986, p. 20-25.

The flying qualities of the Gulfstream IV prototype serial number 1001 are described on the basis of hands-on experience. The aircraft has a range of 3000 n. mi. at Mach 0.8 with eight passengers at a cruise altitude of 41,000 ft. The 12,420 lb thrust Tay engines have achieved sound levels which are sufficient for nighttime operations into noise-sensitive airports. The computerized avionics have electromechanical horizon, Mach/airspeed and altimeter as backups in case of total computer failure. Both the pilot and co-pilot have independently functioning primary and navigation displays. The primary display can be switched over to the navigation display if the Primary RT fails. The aircraft carries a standby generator to provide aircraft systems power and two CRT displays in the event of failure of the dual generators driven by the engines. A narrative is provided of a test flight, including subjective reactions to the aircraft handling and avionics display quality. M.S.K.

A87-23260#
STOL/MANEUVER TECHNOLOGY DEMONSTRATOR TEST PROGRAM
P. L. MELGAARD (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 3 p.
(AIAA PAPER 86-9762)

The tests of the STOL and Maneuver Technology Demonstrator program, which is to investigate, develop, and validate technologies aimed at improving STOL capability and maneuverability for fighter aircraft, are examined. The technologies analyzed include: (1) two-dimensional thrust vectoring/reversing engine nozzle; (2) integrate flight/propulsion control system; (3) rough/soft field landing gear; and (4) advanced pilot/vehicle interface. The objectives of the wind tunnel, manned flight simulation, Avionics Laboratory, Iron Bird, on-aircraft ground, taxi, and flight tests are described. Flight and ground test schedules are provided. I.F.

A87-23263#
DATABASE APPLICATION TO AIRCRAFT ENGINEERING FUNCTIONS RELATED TO FLIGHT TESTING
JEROME S. KOHN and JULIUS PANGILINAN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p.
(AIAA PAPER 86-9823)

Attention is given to a database management system currently being developed to provide data control for aircraft engineering groups that produce and evaluate information on planned test conditions, analyze test flight data and provide performance guarantees. Similar capabilities will be offered to flight test organizations who integrate all test requirements, operate complex recording, telemetry, and data output systems, and assume the responsibilities of performance demonstration and flight safety. It is noted that the database system will be structured so that both organizations can control, share, use, and transmit flight test related data in the on-line computer environment. K.K.

N87-15161# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich Transport-und Verkehrsflugzeuge.

PROBLEMS OF THE APPLICATION OF WIND TUNNEL RESULTS TO AERODYNAMIC PERFORMANCE OF LARGE AIRCRAFT

R. HILBIG *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 7-16 Oct. 1985 Transl. into ENGLISH from "Grenzxchichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23713

Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

The utilization of unambiguous, reproducible wind tunnel results as a basis for the prediction of large aircraft performances and properties under flight conditions is discussed. It is shown that unambiguous wind tunnel results are absolutely required in the different aircraft development phases. This unambiguity is only possible with a transition fixing which is demonstrated to be laminar-turbulent. The boundary layer falsification by size and position and the fixing measures have to be minimized. This leads to requirements for the minimum Reynolds number domain that has to be reached in the wind tunnel. Additional experimental information about the boundary layer development under three-dimensional conditions and about the blow-away field are necessary to improve the numerical-experimental method to apply wind tunnel results to flight conditions. ESA

N87-15162# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich Transport-und Verkehrsflugzeug

BOUNDARY LAYER TRANSITION CONTROL FOR TAKEOFF AND LANDING CONFIGURATIONS

H. P. FRANZ *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 17-31 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23714

Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

Wind tunnel test results were scaled to predict aircraft performance at low speed phases, taking into account Reynolds number effects. A possibility to define scaling laws is to fix the boundary layer transition from laminar to turbulent spatially in the model by artificial surface roughness. The boundary layer transition control has to be demonstrated by preliminary tests. The practical realization of surface roughness taking into account the required Mach-Reynolds combination and lift value is discussed. The method allows scaling to large aircraft of project-aerodynamic performance prediction. ESA

N87-15163# National Aerospace Lab., Amsterdam (Netherlands).

EXPERIENCES WITH TRANSITION FIXING IN THE HIGH SPEED REGIME AT NLR, NETHERLANDS

A. ELSENAAR *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 33-56 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23715

Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

Transition fixing for transonic transport-type aircraft configurations is discussed. The use of wind tunnel measurements for flight prediction is explained, and practical problems of the fixing technique are discussed. Tests with free transition are qualitatively not representative for full scale. In order to predict flight conditions, extrapolation of Reynolds number trends is preferred; the aft-fixing technique is complementary when separations are expected at (low) tunnel Reynolds numbers. ESA

N87-15164# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich Transport-und Verkehrsflugzeuge.

TRANSITION FIXING IN THE HIGH SPEED RANGE FOR THE DEVELOPMENT OF CIVIL AIRCRAFT WINGS

W. BURGSMUELLER *In* ESA Boundary Layer Control by Transition Fixing (ESA-TT-909) p 55-79 Oct. 1985 Transl. into ENGLISH from "Grenzschichtsteverung durch Transitionsfixierung" rept. DFVLR-Mitt-84-17 DFVLR, Goettingen, West Germany, Sep. 1984 Original language document was announced as N85-23716

Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 39

Boundary layer transition fixing for the prediction of Airbus performance is discussed. Comparative measurements were conducted on competing aircraft. The effects of strip position and grain size on transition fixing are presented. The Delta method is used to determine the difference between wind tunnel tests and flight tests. The method to predict aircraft performances based on wind tunnel tests is explained. The presented fixing technique is very time consuming. Comparison between wing profiles is possible under certain conditions. The scaling by the Delta method provides usable results. Improvements of the fixing technique are desirable. ESA

N87-15201 Maryland Univ., College Park.

DYNAMIC STABILITY OF HINGELESS AND BEARINGLESS ROTOR BLADES IN FORWARD FLIGHT Ph.D. Thesis

BRAHMANANDA PANDA 1985 183 p

Avail: Univ. Microfilms Order No. DA8608844

The aeroelastic stability of hingeless and bearingless rotor blades in forward flight is examined. Two types of structural modeling are used; a spring-restrained hinged model and a elastic beam model. With a hinged model, the blade is assumed to undergo three degrees of motion; rigid body flap, lag, and feather rotations about hinges at the blade root, with hinge springs to obtain arbitrary natural frequencies. Quasisteady strip theory is used to evaluate the aerodynamic forces and the unsteady aerodynamics effects are introduced approximately through a dynamic wake induced inflow modelling. The nonlinear time dependent periodic blade response is calculated using an iterative procedure based on Floquet theory. The periodic perturbation equations are solved for stability using Floquet transition matrix theory as well as constant coefficient approximation in the fixed reference frame. Results are presented for both soft-inplane and stiff-inplane blade configurations and the effects of several parameters on blade stability are examined. For an elastic hingeless model, the blade is assumed to undergo flap bending, lag bending and torsional deflections. A finite element formulation based on Hamilton's principle is used. Dissert. Abstr.

N87-15203# Royal Aircraft Establishment, Farnborough (England).

THE DYNAMIC SCALING AND DEVELOPMENT OF MODEL HELICOPTER ROTOR BLADES FOR THE RAE 24FT WIND TUNNEL TEST RIG

C. HATCH May 1985 27 p

(RAE-TR-85052; RAE-MAT/STRUCT-128; BR97932; ETN-86-98373) Avail: NTIS HC A03/MF A01

The design considerations for scale model helicopter rotors for wind tunnel testing are discussed. The laws governing the scaling of dynamic characteristics, in terms of loads, vibration modes and displacements, are derived, and generalized to include the case of unequal scaling of span and chord. For tests in a 24ft wind tunnel, dynamically scaled blades based on a composite D-spar construction were used. The design and dynamic characteristics of these blades is described. Blades with a significantly lower torsional stiffness are needed; results of experiments to modify the existing blades, by changes to the D-spar, show that this type of construction is unsuited to future requirements. An alternative construction method, based on a CFRP inner spar, rigid foam fairing and GFRP skin, is shown to

have the versatility to meet the requirements for dynamically scaled blades. ESA

N87-15204# Battelle Columbus Labs., Ohio.
HANDBOOK. VOLUME 1: VALIDATION OF DIGITAL SYSTEMS IN AVIONICS AND FLIGHT CONTROL APPLICATIONS
ELLIS F. HITT, DONALD ELDREDGE, JEFF WEBB, CHARLES LUCIUS, and MICHAEL S. BRIDGMAN 1986 516 p Sponsored by FAA
(DOT/FAA/CT-82/115-VOL-1-REV) Avail: NTIS HC A22/MF A01

Techniques, methodologies, tools, and procedures are identified in a systems context that is applicable to aspects of the validation and certification of digital systems at specific times in the development, and implementation of software based digital systems to be used in flight control/avionics applications. The application of these techniques in the development of discrete units and/or systems will result in completion of a product or sytem which is verifiable and can be validated in the context of the existing regulations/orders of the government regulatory agencies. A systems engineering approach is used to implement and test the software and hardware during the design, development, and implementation phase. The handbook also recognizes and provides for the evaluation of the pilot workload in the utilization of the new control/display technology, especially when crew recognition and intervention may be necessary to cope with/recover from the effects of faults or failures in the digital systems or the crew introduces errors into the system under periods of high workload due to some inadvertent procedure or entry of incorrect or erroneous data. B.G.

N87-15205*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERDISCIPLINARY AND MULTILEVEL OPTIMUM DESIGN
JAROSLAW SOBIESZCZANSKI-SOBIESKI and RAPHAEL T. HAFTKA Dec. 1986 49 p Presented at the NATO Advanced Study Inst. on Computer Aided Optimal Design, Troia, Portugal, Jul. 1986
(NASA-TM-89077; NAS 1.15:89077) Avail: NTIS HC A03/MF A01 CSCL 01C

Interactions among engineering disciplines and subsystems in engineering system design are surveyed and specific instances of such interactions are described. Examination of the interactions that a traditional design process in which the numerical values of major design variables are decided consecutively is likely to lead to a suboptimal design. Supporting numerical examples are a glider and a space antenna. Under an alternative approach introduced, the design and its sensitivity data from the subsystems and disciplines are generated concurrently and then made available to the system designer enabling him to modify the system design so as to improve its performance. Examples of a framework structure and an airliner wing illustrate that approach. Author

N87-15207# Esprit Technology, Inc., Walnut Creek, Calif.
SMALL, SELF-CONTAINED AIRCRAFT FATIGUE DATA RECORDER Final Report, Oct. 1985 - Aug. 1986
PHILIP FLANNER Aug. 1986 164 p
(Contract N62269-85-C-0716)
(AD-A172400) Avail: NTIS HC A08/MF A01 CSCL 20K

Because of aging airframes and more severe mission requirements, the need to monitor structural fatigue damage on military aircraft has become critical. It is particularly important to be able to study the dynamic loads in remote locations such as the vertical tail, wing spar, landing gear, etc. However, there is presently no small, battery-operated data recorder available to investigate fatigue characteristics at these localized stress hot spots. Having available a miniature data-logger that could be easily attached to any desired location on an aircraft will enable engineers to quickly examine, and correct, the cause of fatigue cracks and similar structural problems. The purpose of this program was to investigate the feasibility of utilizing the latest technology in low-power circuitry, transducers and packaging to produce a small, rugged, self-contained fatigue recorder, requiring no tie-in to aircraft wiring for installation. The project stages included: feasibility study, design evaluation, submittal of an interim report, and culminated in the design layout and construction of a brassboard demonstration unit. This feasibility demonstrator is a single channel device connected to an internal accelerometer and includes a means for automatically activating the micro-processor circuitry by sensing the vibration associated with the start-up and operation of the aircraft's engines. Size of the ultimate unit is targeted at 8 cubic inches. GRA

N87-15957 Stanford Univ., Calif.
DYNAMICS OF A HELICOPTER WITH A SLING LOAD Ph.D. Thesis
TUVYA RONEN 1986 239 p
Avail: Univ. Microfilms Order No. DA8608217

The operations of helicopters carrying externally slung loads are often hampered by stability and control problems. To develop control schemes for alleviating these problems, it is necessary to have a good dynamic model for the helicopter and sling load system. Therefore the goals of this work are to improve the existing dynamic models for single point suspensions, especially in the area of load aerodynamics, and to investigate the open loop characteristics of the system. The model is intended for use in designing control schemes for helicopters with sling loads. The equations of motion (EOM) of the helicopter-load system are derived for a single point suspension. The dynamic model treats both the helicopter and the load as rigid bodies, each subjected to inertial and aerodynamic forces and moments. The formulation is applicable to various types of helicopters, loads, and versions of a single point suspension. The nonlinear EOM are derived first, and then separated into two sets: nonlinear trim equations, and linearized EOM for small perturbation about the equilibrium. The linearized equations are symmetric--the equations for the helicopter and the load are similar, being as close a possible to the standard form of EOM of a single flight vehicle. The dynamic model takes into account the effect of the downwash of the rotor on the dynamics of the load. Momentum theory is used to approximate the downwash and to predict the wake boundaries.
Dissert. Abstr.

N87-15959*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE-SCALE STATIC INVESTIGATION OF CIRCULATION-CONTROL-WING CONCEPTS APPLIED TO UPPER SURFACE-BLOWING AIRCRAFT
M. D. SHOVLIN, R. J. ENGLAR (Naval Ship Research and Development Center, Bethesda, Md.), J. C. EPPEL, and J. H. NICHOLS, JR. Jan. 1987 65 p
(NASA-TP-2684; NAS 1.60:2684) Avail: NTIS HC A04/MF A01 CSCL 01C

The use of a circulation control to deflect turbofan engine thrust beyond 90 deg. has been proven in full-scale static ground tests of the circulation-control-wing/upper-surface-blowing (CCW/USB) concept. This powered high-lift system employs a circular, blown trailing edge to replace the USB mechanical flaps to entrain engine-exhaust flow, and to obtain both a vertical-thrust component and an augmented circulation lift for short takeoff and landing (STOL) applications. Previous tests (Phase 1), done in 1982, of a basic configuration installed on the Quiet Short Haul Research Aircraft confirmed these CCW/USB systems capabilities. A second phase (Phase 2) of full-scale, static, thrust-deflection investigations has reconfirmed the ability to deflect engine thrust from 40 to 102 deg., depending on thrust level. Five new configurations were evaluated and performance improvements noted for those configurations with larger blown span, fences or favorable engine interactions, smaller slot height, and larger radii with less than 180 deg. of CCW surface arc. In general, a 90 deg. circular arc with a smaller slot height provided the best performance, demonstrating that adequate thrust turning can be produced by a trailing-edge shape which may have minimal cruise-performance penalty. Thrust deflections were achieved at considerably lower blowing momentum than was required for the baseline case of Phase 1. Improved performance and versatility

were thus confirmed for the CCW/USB system applied to STOL aircraft, where the potential for developing a non-moving-parts pneumatic thrust deflector to rapidly vary horizontal force from thrust to drag, while maintaining constant vertical force, appears quite promising. The conversion from high-lift to lower-drag cruise mode by merely terminating the blowing provides an effective STOL aircraft system. Author

N87-15961# Dikewood Corp., Albuquerque, N. Mex.
PROCESSING, EVALUATION AND ANALYSIS OF THE MAGNETIC FIELD DATA ACQUIRED BY THE F-106 NOSE BOOM SENSOR Final Report, Jun. 1983 - Apr. 1985
D. V. GIRI and S. H. SANDS Jun. 1986 57 p Prepared in cooperation with LuTech, Inc., Lafayette, Calif.
(Contract F29601-82-C-0027)
(AD-A172180; DC-FR-1026.3E0-1A; AFWL-TR-85-93) Avail: NTIS HC A04/MF A01 CSCL 14B

The theoretical development useful in designing an airborne platform for transient or broadband CW electromagnetic field measurement was reported. These theoretical considerations were applied in specifically designing a nose boom B-dot sensor for the NASA F-106B aircraft. Based on this design and some refinements, the Air Force Weapons Laboratory procured such a sensor. During the EMP testing of the NASA F-106B aircraft (February to March 1984 at Kirtland AFB, N. Mex.), extensive data were gathered by the nose boom sensor in various aircraft/simulator configurations. This report documents all of the nose boom data given to LuTech, Inc. The results of processing and analysis accomplished with the given resources are presented in this report. Some additional processing methods appear possible in the future efforts of this nature. GRA

N87-15962# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
DESIGN OF AIRCRAFT (SELECTED CHAPTERS)
A. A. BADYAGIN, S. M. YEGER, V. F. MISHIN, F. I. SKLYANSKIY, and N. A. FOMIN 22 Sep. 1986 706 p Transl. into ENGLISH from mono. "Proyektirovaniye Samoletov" Moscow, USSR, 1972 p 1-164, 189-226, 420-515
(AD-A172865; FTD-ID(RS)T-0684-86) Avail: NTIS HC A99/MF A02 CSCL 01C

General bases and methods of designing aircraft are presented, along with selections of diagrams, power plants and fundamental parameter of aircraft design. This second edition includes the new materials: the methods of optimum design with the use of computers, the method of the gradients of takeoff weight for the evaluation of the designing solutions and conversion of weight characteristics, special feature of the design of aircraft with the shortened and vertical takeoff, the passenger and aerospace aircraft. Sections, which relate taking into consideration of requirements of economy and to design of main aggregates, are considerably expanded and reworked. Appendices to the book are supplemented by characteristics of aircraft engines, by standard combined weight and enumeration of standard electronic equipment. GRA

N87-15963# Aeronautical Research Labs., Melbourne (Australia).
HELICOPTER HOVER PERFORMANCE ESTIMATION COMPARISON WITH UH-IH IROQUOIS FLIGHT DATA
M. J. WILLIAMS and A. M. ARNEY Apr. 1986 38 p
(AD-A173707; ARL-AERO-TM-377) Avail: NTIS HC A03/MF A01 CSCL 01B

The hover performance of the UH-IH Iroquois has been estimated under a variety of operational conditions using POLAR2, a program based on blade element theory. This program is an improved version of POLAR, a program previously developed at ARL, which did not allow for compressibility effects. The occurrence of these effects in a hovering situation is discussed, and a relationship allowing for such effects has been derived and included in POLAR2. Other improvements, designed to make the program more convenient ot use include the calculation of tail rotor performance together with variables such as tip loss, air density and Lock number which were previously input. The role of the induced velocity factor is also discussed. Finally, comparisons of estimates using POLAR2 and ARDU flight trials data for the UH-IH are presented. GRA

N87-15964# Air Force Packaging Evaluation Agency, Wright-Patterson AFB, Ohio.
QUALIFICATION TESTING OF REDESIGNED F-15/F-4 600 GALLON BI-PAC FUEL TANK CONTAINER
EILEEN T. FOLEY Aug. 1986 31 p
(AD-A173968) Avail: NTIS HC A03/MF A01 CSCL 21D

In 1985 the F-15/F-4 600 Gallon Bi Pac Container was redesigned. Modifications were incorporated into contract F09063-83-C-1178. Qualification tests were conducted on two production containers in accordance with Federal Test Method Standard No. 101 and Military Standard 648. This test report summarizes the results of the tests and recommends modifications which should be included in current and future production contracts. The redesign F-15/F-4 600 Gallon Bi Pac Fuel Tank Container did not pass all of the required tests. Design changes are recommended to ensure the integrity of the containers and the fuel tanks during shipment and storage. GRA

N87-15965*# United Technologies Research Center, East Hartford, Conn.
AN EXPERIMENTAL INVESTIGATION OF THE STRUCTURAL DYNAMICS OF A TORSIONALLY SOFT ROTOR IN VACUUM Contractor Report, Jun. 1984 - Jun. 1986
A. V. SRINIVASAN, D. G. CUTTS, and H. T. SHU Jul. 1986 96 p
(Contract NAS2-11942)
(NASA-CR-177418; NAS 1.26:177418; AD-A172131; UTRC/R86-956877-19) Avail: NTIS HC A05/MF A01 CSCL 20D

An extensive data base of structural dynamic characteristics has been generated from an experimental program conducted on a torsionally soft two-bladed model helicopter rotor system. Measurements of vibratory strains for five modes of vibration were made at twenty-one locations on the two blades at speeds varying from 0 to 1000 RPM and for several combinations of precone, droop and flexure stiffness. Tests were conducted in vacuum under carefully controlled conditions using a unique excitation device with a system of piezoelectric crystals bonded to the blade surface near the root. Frequencies, strain mode shapes and dampings are extracted from the time histories and can be used to validate structural dynamics codes. The dynamics of the system are such that there is a clear tendency for the first torsion and second flap modes to couple within the speed range considered. Strain mode shapes vary significantly with speed and configuration. This feature is important in the calcualtion of aeroelastic instabilities. The tension axis tests confirmed that the modulus-weighted centroid for the nonhomogeneous airfoil is slightly off the mass centroid and validated previous static tests done to determine location of the tension axis. GRA

N87-15966# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
ROTORCRAFT ICING: PROGRESS AND POTENTIAL
Sep. 1986 140 p
(AGARD-AR-223; ISBN-92-835-1535-8) Avail: NTIS HC A07/MF A01

Helicopter icing remains a significant operational consideration for military helicopters operating throughout Europe and northern parts of North America. The working group (WG09) considered the following objectives: (1) to examine rotorcraft icing analysis and modeling; (2) to consider new methods of ice protection; (3) to compare operational experience with ice protected rotorcraft with the design and qualification criteria presently established. The findings of an international group are presented including a comparison of icing atmosphere models and forecasting techniques and an assessment of predictive methods and simulation, flight

clearance strategies and requirements. Various new methods of icing protection for rotorcraft are considered. Author

N87-16002# Naval Air Systems Command, Washington, D. C.
NAVY TECHNOLOGY REQUIREMENTS FOR UNMANNED AIRBORNE VEHICLES
P. E. MULLOWNEY *In* AGARD Guidance, Control and Positioning of Future Precision Guided Stand-Off Weapons Systems 5 p Jun. 1986
Avail: NTIS HC A12/MF A01

Navy technology requirements for unmanned airborne vehicles are most unique in their shipboard launch, recovery, and maintainability. The current and future Remotely Piloted Vehicle (RPV) programs will demand cost and mission effective systems with a high degree of survivability. Cost effectiveness will be emphasized from the shipboard operation end of the problem, starting with storage, launch, remote piloting and data acquisition, through the tradeoff of expendability versus recovery, and shipboard maintenance and Instrument Landing System (ILS) concepts. Until the technology can provide RPVs fully integrated with shipboard operations, Navy applications will remain the same. B.G.

N87-16011# Naval Air Development Center, Warminster, Pa. Aero Analysis Div.
HIGH ALTITUDE, LONG ENDURANCE RPV DESIGN TECHNOLOGY STUDY
CAMPBELL HENDERSON, EDWARD MCQUILLEN, and LARRY LEHMAN *In* AGARD Guidance, Control and Positioning of Future Precision Guided Stand-Off Weapons Systems 14 p Jun. 1986
Avail: NTIS HC A12/MF A01

The Naval Air Development Center conducted a design technology study of high altitude long endurance Remotely Piloted Vehicles (RPVs) for possible mission applications which might include surveillance, over the horizon communications, and targeting, among others. Phase 1 was to investigate technology levels and potential technology breakthroughs that can provide vehicle endurance of greater than 100 hours at altitudes greater than 60,000 feet, and to incorporate the technologies into conceptual vehicle designs. Thes results are presented. Author

N87-16187# Joint Publications Research Service, Arlington, Va.
OPTIMUM BEARING SURFACES OF WINGS WITH INTRICATE GEOMETRY FOR SUPERSONIC FLIGHT Abstract Only
YE. M. PROKHOROV *In its* USSR Report: Engineering and Equipment p 1 26 Aug. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 6, Nov. - Dec. 1985 p 154-160
Avail: NTIS HC A05/MF A01

The bearing surface of a wing for supersonic flight is optimized with respect to minimum strain and pitch. The optimum shape of this surface is sought in the class of piecewise-constant functions describing it. The problem is solved so as to satisfy all constraints of the linear theory and with a high degree of smoothness. Use of two computational grids shifted from one another eliminates the need for smoothing the resistance coefficients fo drag and lift. Calculations were made for a delta wing with 76 to 57 degree broken-line front edges in the plane view, the target being to ensure nonseparation flow and zero load on the subsonic front edges at the supersonic velocity N sub M = 2. Author

N87-16189# Joint Publications Research Service, Arlington, Va.
NONLINEAR INTEGRO-DIFFERENTIAL EQUATIONS FOR AEROELASTICITY
I. S. ASTAPOV, A. S. BELOTSERKOVSKIY, and V. I. MOROZOV *In its* USSR Report: Engineering and Equipment p 44-45 26 Aug. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Tverkogo Tela (Moscow, USSR), no. 6, Nov. - Dec. 1985 p 61-70 Original language document was announced in IAA as A86-24287
Avail: NTIS HC A05/MF A01

Nonlinear integro-differential nonstationary aeroelasticity equations are obtained for the general case of the three-dimensional motion of an elastic flight vehicle with loads in a nonstationary gas flow. Cauchy formulas for the Volterra integro-differential equations, unresolved with respect to the derivative, are presented. The formulas presented here are used for analyzing the stability, in the sense of Liapunov, of solutions to the integro-differential nonstationary aeroelasticity equations in the case where the integral kernels are replaced by approximation functions, with allowance made for the nonlinearity and motion parameters that are explicitly time-dependent. IAA

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-19629
CHARACTERISTICS AND SPECIFICATION OF AIRBORNE FIBER OPTIC COMPONENTS
W. SCHNEIDER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Optical fiber characteristics and standards; Proceedings of the Meeting, Cannes, France, November 25-27, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 107-114. refs

The specifications for airborne optic components applicable to data buses in commercial and military aircraft are described. The need for an optical fiber with good handling qualities, reliability, lifetime, and survivability in a severe environment is discussed. It is required that the airborne fiber optic cables have a small diameter, low weight, and good temperature performance as well as being rugged and resistant to compressive loading crush load, impact, and corner bends. The designs for fiber optic connectors and fiber optic couplers are examined. I.F.

A87-19684
THE DESIGN AND MANUFACTURE OF A LARGE ZINC SULPHIDE WINDOW FOR AN AIRBORNE APPLICATION
E. S. CAMERON (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) and G. CARTLEDGE (Royal Aircraft Establishment, Farnborough, England) IN: Infrared technology and applications; Proceedings of the Meeting, Cannes, France, November 26-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 93-99. Research supported by the Ministry of Defence of England. refs

The design and manufacture of a large chisel window assembly is reviewed, the intended application being for a mirror-stabilized narrow field of view thermal imager in a high speed aircraft. Aerodynamic heating was expected to be significant, and this placed restrictions on the choice of material and the configuration of the window assembly. The practical problems of procurement and manufacture are discussed, including material supply, edging, polishing, coating and assembly. The results of IR interferometric tests on individual panes and on the final assembly are presented. The window is shown to achieve diffraction-limited performance, while being capable of withstanding high temperature and pressures, and is resistant to rain erosion. Author

A87-19695
IN-FLIGHT RESOLUTION AND SENSITIVITY EVALUATION FOR AIRBORNE THERMAL IMAGING SYSTEMS
STEVEN E. SHIMER and JOHN L. MINOR (USAF, Avionics Div., Edwards AFB, CA) IN: Infrared technology and applications; Proceedings of the Meeting, Cannes, France, November 26-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 364-374.

This paper presents methods used to quantify the resolution and thermal sensitivity of an airborne Thermal Imaging System (TIS) in the in-flight environment. By determining in-flight resolution and sensitivity of the total system including sensor, aircraft interface, display and pilot, a realistic measure of the system's true operational performance capabilities can be determined. The

effects of target radiation and atmospheric transmittance are included in the evaluation. Descriptions of two types of aircraft systems, the Single Seat Night Attack (SSNA) A-10 and the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN), are presented. Author

A87-20797
'LOST' DATA RECOVERY TECHNIQUE
GARTH HESS (Lockheed Aircraft Service Co., Ontario, CA) Lockheed Horizons (ISSN 0459-6773), Sept. 1986, p. 32-38.

A technique for analyzing aircraft flight data is described. The technique graphically displays the actual raw waveform of the data on a long strip chart; a bit-waveform sequence of a representative sync word for the flight data is produced. An FM carrier method and a voltage-controlled oscillator, designed using a portion of a phase-lock loop chip, are employed in the technique. Examples displaying the application of this technique to flight data from aircraft crashes are presented. Following the evaluation of flight data using the technique, the bit-detection margins, feedback networks, waveform zero-crossing time precision, and analog-signal multiplexing were improved. I.F.

A87-20951
A THERMAL DEVICE FOR AIRCRAFT MEASUREMENT OF THE SOLID WATER CONTENT OF CLOUDS
W. D. KING and D. E. TURVEY (CSIRO, Cloud Physics Laboratory, Sydney, Australia) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 3, Sept. 1986, p. 356-362. refs

A constant temperature probe for the measurement of solid water content of clouds is described. The probe is operated at a temperature of 25 C, and is designed to collect and melt ice particles that impact in an open half-cylinder, the amount of power supplied to the probe being related to the solid water content through its dimensions, etc. Comparisons in a small wind tunnel with values derived from weighings of oil-coated slides suggests that the probe is accurate to about 50 percent, while data from two different aircraft indicate that it performs reliably under flight conditions. Author

A87-20958
AIR FLOW AND PARTICLE TRAJECTORIES AROUND AIRCRAFT FUSELAGES. IV - ORIENTATION OF ICE CRYSTALS
W. D. KING (National Center for Atmospheric Research, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 3, Sept. 1986, p. 433-439. refs

The equations of motion for an ice crystal moving around a body are simplified and used to obtain the preferred angular orientation of the crystals with respect to the body. It is shown that the calculated orientation angles are in good agreement with those measured by under-wing probes, and that the major cause of the preferential orientation of columns is the vortex generated at the tips of finite wings. It is also shown that a preferred orientation can be found in data obtained using fuselage-mounted probes, but there the agreement between the calculated and observed angles is not as good. Author

A87-20964*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MULTIWAVELENGTH SCANNING RADIOMETER FOR AIRBORNE MEASUREMENTS OF SCATTERED RADIATION WITHIN CLOUDS
MICHAEL D. KING, MAXWELL G. STRANGE, PETER LEONE, and LAMDIN R. BLAINE (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 3, Sept. 1986, p. 513-522. refs
(Contract NSF ATM-82-18978)

A multi-wavelength scanning radiometer has been developed for measuring the angular distribution of scattered radiation deep within a cloud layer. The purpose of the instrument is to provide measurements from which the single scattering albedo of clouds can be derived as a function of wavelength. The radiometer has a 1-deg field of view and scans in the vertical plane from 5 deg before zenith to 5 deg past nadir (190 deg aperture). The thirteen channels of the cloud absorption radiometer are located between 0.5 and 2.3 microns and were selected to avoid the molecular absorption bands in the near-infrared. The first seven channels of the radiometer are simultaneously and continuously sampled, while the eighth registered channel is selected from among the six channels on a filter wheel. This paper describes the optical, mechanical and electrical design of the instrument and presents some early results obtained from measurements taken aboard the University of Washington's B-23 aircraft to illustrate the performance of the instrument. Author

A87-21074#
AN ULTRASONIC SENSOR FOR THE DETECTION AND MEASUREMENT OF THE THICKNESS OF ICE ON AN AIRFOIL [CAPTEUR ULTRASONORE POUR LA DETECTION ET LA MESURE D'EPAISSEUR DE GIVRE SUR UN PROFIL]
J. C. GARNIER, A. D. DEOM, D. L. BALAGEAS, and J. J. CASSAING (ONERA, Chatillon-sous-Bagneux, France) (Colloque International sur la Securite Aerienne, 2nd, Toulouse, France, Nov. 17-20, 1986) ONERA, TP, no. 1986-175, 1986, 11 p. In French. (ONERA, TP NO. 1986-175)

The theoretical basis, design and capabilities of an ultrasonic ice detector for monitoring airfoil icing are summarized. A piezoelectric sensor is coupled, from within, to the airfoil by means of a material which causes a slight acoustic delay. The sensor emits ultrasonic signals to the surface susceptible to icing. Since waves are transmitted and backscattered whenever the ambient medium changes, signals return from both the airfoil-ice and ice-air interfaces. The differential return times are analyzed to extract the ice thickness. Laboratory data are cited to demonstrate the sensor sensitivity to ice layers of a few millimeters. M.S.K.

A87-21175
EUROFIGHTER AVIONICS - HOW ADVANCED?
GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 130, Oct. 24, 1986, p. 28, 29.

The development of the European fighter aircraft (EFA) is discussed. The requirements for the radar, which is to effectively use beyond-visual-range weapons, are described; the pulse repetition mode of operation and the NATO identification system for the EFA radar are examined. The development of a wide-angle, diffractive-optics head-up display using a computer-generated hologram and of three full-color head-down multifunction displays for the man/machine interface is studied. Consideration is given to the use of a helmet-mounted display and voice control on the EFA. I.F.

A87-21253#
TOWARD THE OMNIPOTENT PILOT
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1986, p. 18-20, 22.

The features and capabilities of the supercockpit project, planned for use in military aircraft, are described. The LHX-developed helmet (which will weigh only 3.5 lb) will feature translucent displays and can also be worn on the ground as a simulator. A pilot wearing the device will be able to see any sensor data, including IR imaging and computer-processed radar results for locations of friendly and enemy aircraft, navigational waymarks, and targets, superimposed either over his whole field of view or part of it. Ultrafast superchips that will perform five million floating point operations per second are being developed for the operational use of the helmet, planned for the mid-1990s. I.S.

A87-22471#
AIRBORNE INFRARED WIND SHEAR DETECTOR PERFORMANCE IN RAIN OBSCURATION
PETER M. KUHN (ARIS, Inc., Boulder, CO) and PETER C. SINCLAIR (ARIS, Inc., Fort Collins, CO) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p.
(AIAA PAPER 87-0186)

The testing of the operational performance of the airborne, infrared wind shear sensing system entailed aircraft flights in and through light and moderate rain. The system has been flown primarily only in clear conditions. The algorithms applied to the radiometer output for shear alert processing that had functioned in clear conditions were applied in rain obscuration. The airborne, infrared shear detection and avoidance system produced an 87 percent success rate in detection low altitude shear before encounters from 40 to 60 seconds prior to the eight encounters. All events occurred during light and some moderate rain. The false alarm rate for eleven no-shear flights was 18 percent but this can probably be improved with a scanning and multiple filter system. Author

A87-22797* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
AIRBORNE DOPPLER LIDAR MEASUREMENTS
JAMES W. BILBRO, D. FITZJARRALD, S. JOHNSON, W. JONES (NASA, Marshall Space Flight Center, Huntsville, AL), and C. DIMARZIO (Raytheon Co., Sudbury, MA) Applied Optics (ISSN 0003-6935), vol. 25, Nov. 1, 1986, p. 3952-3960.

This paper describes recent measurements using coherent Doppler lidars operating at a wavelength of 10.6 microns aboard the NASA Ames Convair 990. The purpose of the measurements was to obtain data on the atmospheric wind fields and the distribution of the backscatter coefficient at 10.6 microns. A decription of the instruments is provided detailing the modifications incorporated following the 1981 test flights of the systems. The measurement program is outlined, and preliminary results are discussed. Author

N87-15967 ESDU International Ltd., London (England).
INTRODUCTION TO AIR DATA SYSTEM PARAMETERS, ERRORS AND CALIBRATION LAWS
Nov. 1986 20 p Supersedes ESDU-RG1/0
(ESDU-86031; ISBN-0-85679-583-6; ISSN-0141-4054) Avail: ESDU

ESDU 86031 provides an introduction to a series of Items which deal with particular aspects of corrections to air data system measurements. The constituent parts of typical air data systems are described, and the notation convention used througout the series of Items introduced. All relevant air data system parameters are defined and a tabular index to calculation procedures is included. A separate section gives the calibration laws for altimeter, airspeed indicator and Machmeter. ESDU

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboa rd auxiliary power plants for aircraft.

A87-20400
A METHOD FOR EVALUATING THE EFFECT OF THE RADIAL CLEARANCE ON THE EFFICIENCY OF THE TURBOCOMPRESSOR DURING THE SELECTION OF PROCESS PARAMETERS FOR A TURBOFAN ENGINE [METOD OTSENKI VLIIANIIA RADIAL'NOGO ZAZORO NA KPD TURBOKOMPRESSORA NA ETAPE VYBORA PARAMETROV RABOCHEGO PROTSESSA TRDD]
E. D. STENKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 79-82. In Russian. refs

Formulas are obtained for determining the polytropic and isentropic efficiency of the compressors and turbines of turbofan engines with allowance for the effect of radial clearances. Calculations based on these formulas indicate that radial clearances significantly effect the efficiency. It is noted that the use of the method is limited to the stage of preliminary design at which the rotor parameters are selected. New turbine designs with variable radial clearances, currently under development, will make it possible to minimize the clearances at cruising speeds and to stabilize them in operation; they will also call for a further refinement of the methods for evaluating the effect of the clearance on the efficiency. V.L.

A87-20401
A STUDY OF HEAT RELEASE IN THE PRIMARY ZONE OF THE COMBUSTION CHAMBER OF A GAS-TURBINE ENGINE [ISSLEDOVANIE TEPLOVYDELENIIA V PERVICHNOI ZONE KAMERY SGORANIIA GTD]
V. G. CHUMACHENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 82-84. In Russian.

The effect of the mixture composition in the combustion chamber on heat release in the primary zone is investigated experimentally as a function of the primary zone length and burner location within the zone. It is shown that in combustion chambers using a prevaporized fuel, a reduction in the length of the primary zone from 0.68 to 0.35 gauge does not affect heat release within the chamber. Heat release in the primary zone is shown to decrease abruptly with mixture enrichment starting with an air excess ratio of 0.6. V.L.

A87-20937
MOVING CLOSER TO FULLY INTEGRATED CONTROL
JAMES H. BRAHNEY *Aerospace Engineering* (ISSN 0736-2536), vol. 6, Oct. 1986, p. 34-39.

An evaluation is made of prospects for the integration of propulsion control and flight control systems in next-generation combat aircraft. One of the key elements that will be involved in any such integration is an advanced fuel management system, which has been shown to enhance the overall reliability and performance of control systems. Attention is given to the results of these fuel management system demonstration tests, which were conducted with a PWA 691 Joint Technology Demonstrator Engine. O.C.

A87-21025#
AN EXPERIMENTAL DETERMINATION OF THE TRANSFER LAWS FOR A DISTURBANCE ACROSS AN AXIAL COMPRESSOR [DETERMINATION EXPERIMENTALE DES LOIS DE TRANSFERT DE PERTURBATIONS A LA TRAVERSEE D'UN COMPRESSEUR AXIAL]
JACQUES HUARD (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Engine Response to Distorted Inflow Conditions, Munich, West Germany, Sept. 8, 9, 1986) ONERA, TP, no. 1986-106, 1986, 12 p. In French. DRET-supported research.
(ONERA, TP NO. 1986-106)

Transfer equations were identifed for disturbances introduced into an axial flow compressor by disturbances to the flow across the inlet. The rotating blade rows are represented as a semi-actuator disk and aerothermodynamic values of the flow upstream and downstream of the disk are related by the transfer equations. The equations were derived from experimental data on the displacement of streamlines and the pressure changes after a distortion screen upstream from a blade row. Upstream flow distortions had a linear quasi-sinusoidal periodicity, while those between rows varied bilinearly. M.S.K.

A87-21089#
THE INFLUENCE OF RADIATION ON THE THERMAL EQUILIBRIUM OF A FEEDER TURBINE OF A TURBOJET [INFLUENCE DU RAYONNEMENT SUR L'EQUILIBRE THERMIQUE D'UNE AUBE DE TURBINE DISTRIBUTRICE DE TURBOREACTEUR]
JOEL GUIDEZ (Societe Francaise des Thermiciens, Journee d'Etude sur le Rayonnement et Recherches Aeronautiques et Aerospatiales, Paris, France, Nov. 26, 1986) ONERA, TP, no. 1986-190, 1986, 26 p. In French. refs
(ONERA, TP NO. 1986-190)

An analytical study is performed to determine the impact of the radiation flux absorbed and emitted by a high pressure first stage feeder blade in a gas turbine. Accurate modeling of the radiation balance is essential for keeping air-cooled blades at the design temperature of around 1300 K and the flow at about 1800 K to maintain thermodynamic efficiency. Account is taken of the radiation flux from the hot gases, the turbine components and walls, and the blade mount. A net flux model is defined to calculate the radiative balance between the blade configuration and its environment. Radiation is found to never exceed 20 percent the magnitude of convective heat transfer. M.S.K.

A87-21507#
EVALUATION OF A FREE-JET TECHNIQUE FOR TESTING FIGHTER AIRCRAFT PROPULSION SYSTEMS
D. K. BEALE (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(AIAA PAPER 86-1460)

Subscale free-jet inlet model tests were conducted to evaluate the free-jet test technique for inlet-engine compatibility assessment. A 15-percent-scale model of the General Dynamics F-16 inlet was selected for the work. Designed for wind tunnel inlet component tests, the model was instrumented with probes for measuring steady-state and time-variant inlet distortion. The free-jet tests were conducted in a subscale free-jet test facility representative of the Arnold Engineering Development Center (AEDC) Aeropropulsion Systems Test Facility (ASTF) cell C-2. The test technique evaluation was based on comparisons of measured inlet distortion results from an existing wind tunnel data base and the free-jet tests. The experiments were conducted at subsonic Mach numbers ranging from 0.3 to 0.9. Flight angles of attack up to 30 deg were simulated. The free-jet results compared well with the wind tunnel results. The experiments demonstrated that for one specific inlet configuration: (1) inlet distortion characteristics at high angle of attack can be duplicated in the free-jet environment, (2) the influence of the aircraft forebody on the inlet flow in flight can be simulated using a much shorter forebody simulator compatible with free-jet sizing limitations, and (3) flow-field measurements made in front of the inlet can be used to adjust the free-jet test variables, ensuring simulation of flight conditions. Author

A87-21514*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VISUALIZATION OF FLOWS IN A MOTORED ROTARY COMBUSTION ENGINE USING HOLOGRAPHIC INTERFEROMETRY
YOLANDA R. HICKS, HAROLD J. SCHOCK (NASA, Lewis Research Center, Cleveland, OH), JAMES E. CRAIG, HOLLY L. UMSTATTER, and DAVID Y. LEE (Spectron Development Laboratories, Inc., Costa Mesa, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Previously announced in STAR as N86-31583. refs
(AIAA PAPER 86-1557)

The use of holographic interferometry to view the small- and large-scale flow field structures in the combustion chamber of a motored Wankel engine assembly is described. In order that the flow patterns of interest could be observed, small quantities of helium were injected with the intake air. Variation of the air flow patterns with engine speed, helium flow rate, and rotor position are described. The air flow at two locations within the combustion chamber was examined using this technique. Author

A87-21523#
VALIDATION OF AIRCRAFT GAS TURBINE ENGINE STEADY-STATE MATHEMATICAL MODELS
R. S. MCKAMEY (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 32 p.
(AIAA PAPER 86-1741)

Attention is given to turbine engine mathematical model (TEMM) definition and usages, the stages of mathematical model development, and validation procedures. The TEMM is a series of component maps that are integrated using conservation equations to represent the overall scheme. It is noted that mathematical model development closely parallels engine development and that once validated, the TEMM is a low-cost alternative to actual test data. K.K.

A87-22353#
FURTHER DEVELOPMENT OF PNEUMATIC POWERED-LIFT SYSTEMS WITH CAPABILITY FOR THRUST DEFLECTION AND RECOVERY
ROBERT J. ENGLAR (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0005)

Wind tunnel evaluations have been conducted of two pneumatic thrust-deflecting powered-lift systems to develop the capabilities of interchangeable thrust recovery and reversal as well as longitudinal pitch trim. A Circulation Control Wing/Vectored Thrust configuration employed under-wing Pegasus-type nozzles to redirect the horizontal thrust component as needed for STOL operation, and provide nose-up pitching moment for trim. Although they provided a vertical thrust component to lift, the vectoring nozzles were relatively ineffective in augmenting aerodynamic lift. A Circulation Control Wing/Over the Wing blowing configuration pneumatically deflected engine thrust for additional high lift beyond that provided by CCW alone. It also allowed pneumatic conversion of resultant force along the flight path from thrust recovery to thrust reversal as required for takeoff or approach. Both configurations thus offer possible solutions to STOL operational problems, one by pneumatic/mechanical means, and the other primarily pneumatically. Author

A87-22440#
MODELING GAS TURBINE DETERIORATION DUE TO HIGH LEVELS OF DUST INGESTION
PAUL BATCHO AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0144)

The influence of high levels of dust ingestion into a gas turbine engine is evaluated and important qualitative aspects are explored in an attempt to trace the deterioration process. The dependence of performance deterioration on blade erosion is modeled and a functional relationship is arrived at. The effects of surface thinning, leading edge erosion, and tip clearance increase are included in order to model blade losses as completely as possible. The level of damage at which engine stall will occur is discussed and the influence of transient engine response with respect to steady state behavior is explored. Author

A87-22452#
REVISED GUIDELINES FOR PROPFAN INLET DESIGN BASED ON RECENT ANALYTICAL AND TEST EXPERIENCE
B. H. LITTLE, JR. and B. L. HINSON (Lockheed-Georgia Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 17 p. refs
(AIAA PAPER 87-0163)

This paper addresses the problem of designing optimum engine inlets for tractor installations of single rotation propfans. Guidelines presented in a 1982 paper are revised using published results from a number of experimental and analytical studies performed since that time. The results indicate that, contrary to earlier conclusions, aerodynamic drag of the inlet is not a strong factor in inlet selection. The more significant considerations are: (a) blade vibratory stresses induced by the inlet, and (b) total pressure recovery at the inlet face. The study also shows that, using contemporary analytical methods, short S-duct diffusers can be designed to operate at high efficiency in practical installations. Advances in computational fluid dynamic codes for the complex external flow are described. These analytical tools are shown to permit phenomenological predictions and design improvements that were impractical a few years ago. Author

A87-22454#
ACOUSTIC-VORTEX INTERACTIONS AND LOW FREQUENCY OSCILLATIONS IN AXISYMMETRIC COMBUSTORS
K. KAILASANATH, J. H. GARDNER, J. P. BORIS, and E. S. ORAN (U.S.Navy, Naval Research Laboratory, Washington, DC) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. Navy-sponsored research. refs
(AIAA PAPER 87-0165)

A potentially important source of large pressure oscillations in compact ramjets is a combustion instability induced by the interaction of large-scale vortex structures with the acoustic modes of the ramjet. To study these interactions, time-dependent, compressible numerical simulations of the flowfield in an idealized ramjet consisting of an axisymmetric inlet and combustor were performed. The simulations indicate a strong coupling between the flowfield and the acoustics of both the inlet and the combustor. For the cases studied, forcing at the first longitudinal acoustic mode of the combustor induces vortex-rollup near the entrance to the combustor at that frequency. A low frequency oscillation is also observed in all the simulations. The merging pattern of the vortices in the combustor is significantly different for combustors of different lengths. These merging patterns are explained on the basis of an interaction between the vortex-rollup frequency and the observed low frequency. Pressure oscillations in the inlet indicate that the acoustics of the inlet is the source of this low frequency. Changing the length of the inlet or the sonic velocity in the inlet appropriately changes the observed low frequency. Author

A87-22482#
A THREE-DIMENSIONAL GRID GENERATION METHOD FOR GAS-TURBINE COMBUSTOR FLOW COMPUTATIONS
WEI SHYY, MARK E. BRAATEN, and JANET S. SOBER (General Electric Co., Schenectady, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. refs
(AIAA PAPER 87-0204)

A special-purpose code suitable for generating a curvilinear nonorthogonal grid system for gas-turbine combustor flow computations has been produced. The code is capable of handling an arbitrary number of dilution holes with any radii as well as film-cooling slots on the top and bottom surfaces. A zonal approach has been developed to handle the fast length scale variations imposed by the geometric constraints and to minimize the overall computational efforts needed to generate the grids. The code combines partial differential equation and algebraic interpolation methods to generate the grid system. The salient features of the grid characteristics are discussed. Also included are sample results of a 3-D turbulent combusting flow field calculated on the grid system produced by this methodology. Author

A87-22507*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MODEL AND FULL SCALE STUDY OF TWIN SUPERSONIC PLUME RESONANCE
JOHN M. SEINER, JAMES C. MANNING (NASA, Langley Research Center, Hampton, VA), and MICHAEL K. PONTON (PRC Kentron International, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0244)

This paper examines the effect of both nozzle geometry and scale on the twin supersonic plume resonance phenomenon associated with aircraft having engine nozzle center-to-center spacings less than two diameters. Exit plane near field dynamic pressures were measured for both single and dual nozzle operation in 4.7 percent model and full scale under static conditions. The frequencies associated with this phenomenon were predicted to within 5 percent for a full scale F-15 aircraft. Amplitude levels associated with this phenomenon were found to dominate the dynamic pressure fluctuations in the inter-nozzle region, and reach a level near the structural design limit for this aircraft. The model scale studies, which involved both axisymmetric and rectangular geometry, indicated that amplitude levels could be expected to be much higher in flight. High amplitude levels would likely occur in the overexpanded region for axisymmetric geometry, and in the underexpanded region for rectangular geometry. Author

A87-22508#
PREDICTION OF THE INSTALLED PERFORMANCE OF 2D EXHAUST NOZZLES
R. J. G. NORTON (Rolls-Royce, Inc., Atlanta, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0245)

A numeric scheme for predicting the coupled viscous interaction of nozzle and external flows is reported. The application of current and proposed smoothing techniques to flows with strong gradients and discontinuities is discussed. Inviscid and viscous predictions of the performance of a Single Expansion Ramp Nozzle over a range of nozzle pressure ratios in near stagnant external flow compare well with measurements. Author

A87-22510#
MIXING CHARACTERISTICS OF A SUPERSONIC MULTIPLE JET EJECTOR
M. S. CHANDRASEKHARA, A. KROTHAPALLI (Florida State University, Tallahassee), and D. BAGANOFF (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(Contract F49620-79-0189)
(AIAA PAPER 87-0248)

A study of the flow in a supersonic multiple jet ejector is presented. Also, the concept of an equivalent single jet is

introduced. A comparison of the mass and thrust augmentation characteristics of a multiple jet ejector with an ejector using the equivalent single jet shows that the former is distinctly superior. This better performance is due to enhanced mixing of the flow in case of multiple jets. However, the better mixing is not due to acoustic interaction, unlike in the case of a supersonic single jet ejector. Author

A87-22514*# PRC Kentron, Inc., Hampton, Va.
PREDICTION OF ADDED NOISE DUE TO THE EFFECT OF UNSTEADY FLOW ON PUSHER PROPELLERS
M. A. TAKALLU (PRC Kentron, Inc., Hampton, VA) and P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0255)

An analytical/computational study has been conducted to predict the effect of an upstream wing or pylon on the noise of an operating propeller. The wing trailing edge was placed at variable distances (0.1 and 0.3 chord) upstream of a scaled model propeller (SR-2). The wake was modeled using a similarity formulation. The instantaneous pressure distribution on the propeller blades during the passage through the wake was formulated in terms of a time-dependent variation of each blade section's angle of attack and in terms of the shed vortices from the blade trailing edge. It was found that the final expressions for the unsteady loads considerably altered the radiated noise pattern. Predicted noise for various observer positions, rotational speeds and propeller/pylon distances were computed and are presented in terms of the pressure time history. It has been shown that the positioning of a pylon upstream of a propeller indeed increases the noise. Some comparisons with experimental results are also given. Author

A87-22960#
EXPERIMENTAL STUDY OF FLIGHT EFFECT ON FAN NOISE. II - FAN NOISE SOURCE VARIATION DUE TO FLIGHT EFFECT
HIROSHI KOBAYASHI, TADAO TORISAKI, and MITSUO MORITA (National Aerospace Laboratory, Chofu, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Sept. 1986, p. 2909-2916. refs

Clarification of fan noise source variation due to a flight effect is important for a turbofan noise reduction and a noise estimation. A fan noise spectral extent and a range of fan operation influenced by the flight effect were studied experimentally using a large turbofan engine and a geodesic 4-m diameter semisphere inflow control device that can simulate the flight effect on fan noise in static engine tests. The fan noise reduction by the flight effect in a fan approach condition was higher than that in a fan take-off condition because the fan rotor generates blade passing frequency (BPF) tones by itself near the take-off condition. The highest reduced component in fan noise spectra was a fundamental fan BPF tone, whose reduced level was 20 dB at maximum. Higher harmonic BPF tones and a buzz saw noise were also reduced by the flight effect, but a reduction of broadband noise was not evaluated in the whole range of fan operation. Author

A87-23258*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
DEVELOPMENT AND EVALUATION OF A 1 KW PLASMA TORCH IGNITOR FOR SCRAMJETS
TIMOTHY C. WAGNER, WALTER F. OBRIEN (Virginia Polytechnic Institute and State University, Blacksburg, VA), G. BURTON NORTHAM, and JAMES M. EGGERS (NASA, Langley Research Center, Hampton, VA) Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Combustion Meeting, 23rd, Hampton, VA, Oct. 20-24, 1986, Paper. 13 p. refs

A low power, uncooled plasma torch was tested in combination with a new injector design to study ignition and flameholding in hydrogen-fueled supersonic flows. Both semifree jet and ducted tests were conducted in a Mach 2 flow under simulated scramjet combustor conditions at 1 atmosphere static pressure and total temperatures between 1400 and 2800 R. The injector design incorporates a small upstream pilot fuel flow, a step for recirculation, and primary fuel injectors downstream of the recirculation region. Using a 1:1 volumetric mixture of hydrogen and argon, good performance at a simulated flight Mach number of 3.7 is found for a 1-kW torch which is located in the recirculation zone and fueled by the upstream pilot fuel injectors. Spectroscopic measurements verified the presence of hydrogen atoms in the torch exhaust, and it is suggested that hydrogen atoms are responsible for the ignition. R.R.

N87-15210# Calspan Corp., Buffalo, N. Y. Physical Sciences Dept.
GARRETT TFE-731 HP TURBINE STAGE WITHOUT AND WITH COOLING-GAS INJECTION
MICHAEL G. DUNN *In* Von Karman Inst. for Fluid Dynamics Convective Heat Transfer and Film Cooling in Turbo Machinery 36 p 1986
Avail: NTIS HC A21/MF A01

Local heat flux on the stage of a low aspect ratio rotating turbine was measured at realistic flow conditions. Results on the vane and on the blade, without and with NGV injection of coolant gas are presented. The influence of the presence of the rotor on the vane heat-flux distribution is illustrated. Rotor tip and stationary shroud heat-flux distributions as a function of tip/shroud clearance are discussed. The NGV distributions in the absence of injection were compared with flat-plate and STAN 5 predictions. The turbulent flat-plate prediction gives a reasonably good comparison with the data on the pressure surface. On the suction surface, the turbulent flat-plate prediction is conservative, but by a reasonable amount. Over both surfaces of the blade in the absence of upstream injection, reasonable agreement between the data and one or more of the predictions can be demonstrated. ESA

N87-15212# Calspan Corp., Buffalo, N. Y. Physical Sciences Dept.
TIME-RESOLVED HEAT FLUX MEASUREMENT FOR THE ROTOR BLADE OF A TFA-731-2 HP TURBINE
MICHAEL G. DUNN *In* Von Karman Inst. for Fluid Dynamics Convective Heat Transfer and Film Cooling in Turbo Machinery 39 p 1986
Avail: NTIS HC A21/MF A01

An analysis technique and its application using typical data for time-resolved heat flux measurements on the blade of a full-stage rotating turbine is presented. The magnitude of fluctuations in the heat flux value remain significant over the entire suction surface. The magnitude of the fluctuation is largest over the forward portion of the blade and decreases as the trailing edge is approached. However, relative to the time averaged heat flux values at this downstream location, the magnitude of the fluctuations is significant. A fast Fourier transformation analysis of the time-resolved heat flux demonstrates the presence of peaks at the fundamental and first harmonic of the wake cutting frequency. The frequency spectra also demonstrate the presence of energy at frequencies other than wake cutting. ESA

N87-15218# National Aerospace Lab., Tokyo (Japan).
THE NATIONAL GAS TURBINE PROJECTS IN JAPAN. THE FJR-710 TURBOFAN ENGINE PROJECT. THE ADTJ-100 HIGH EFFICIENT GAS TURBINE PROJECT
TOYOAKI YOSHIDA *In* Von Karman Inst. for Fluid Dynamics Convective Heat Transfer and Film Cooling in Turbo Machinery 16 p 1986
Avail: NTIS HC A21/MF A01

Drawings and photographs of a turbofan engine, a quiet airplane, and a gas turbine test laboratory are presented. ESA

N87-15220# Oxford Univ. (England). Dept. of Engineering Science.
UNSTEADY AERODYNAMIC AND HEAT TRANSFER PROCESSES IN A TRANSONIC TURBINE STAGE
D. L. SCHULTZ *In* Von Karman Inst. for Fluid Dynamics Convective Heat Transfer and Film Cooling in Turbo Machinery 32 p 1986 Avail: NTIS HC A21/MF A01

Heat transfer rates and a range of pressures were measured on a highly loaded rotor profile for which the NGV exit flow included strong trailing edge shock waves. It was possible to vary the blade incidence and thus to examine its effect associated with rotor-wake interaction. A set of steady-state (i.e., no wake interaction), heat transfer, and aerodynamic data is presented. One of the most significant transient effects associated with wake blade interaction is the reduction in flow incidence angle. It is demonstrated that there is a substantial reduction in heat transfer rate over the whole of the suction surface which begins at x/s = 20%. The strong shock waves generated by the wake-producing bar when moving at the correct relative velocity has a profound effect on heat transfer rate. ESA

N87-15223# Stuttgart Univ. (West Germany). Sonderforschungsbereich 85.
THERMODYNAMIC AND FLOW MECHANICAL PROBLEMS IN AIRCRAFT AND SPACECRAFT DRIVES. SUMMARY OF CONFERENCE REPORTS FOR 1974, 1975, 1976 [THERMODYNAMISCHE UND STROEMUNGSMECHANISCHE PROBLEME DER LUFT- UND RAUMFAHRTANTRIEBE, SEMINARBERICHT 1974-75-76]
2 Aug. 1976 141 p Partly in ENGLISH and GERMAN
(ETN-87-98750) Avail: NTIS HC A07/MF A01

Spatial supersonic flow through annular cascades; the applicability of the axisymmetric model in the prediction of supersonic flow through annular cascades; and a simple concept for the computation of steady supersonic flow with supply of heat are discussed. The application of laser Raman spectroscopy for local temperature measurements in flames is considered. Turboengines, turborockets, and turboramjet engines are compared for long range and high Mach numbers. Air breathing jet engines for satellite launchers; and integrated turboramjet-rocket hybrid propulsion systems are analyzed. A smoothing procedure for the calculation of flow fields from interferometric measurements is presented.

ESA

N87-15232# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
STUDY OF PARTICULATED FLOWS AND EROSION IN TURBOMACHINERY Final Report, 14 Dec. 1981 - 30 Jun. 1986
W. TABAKOFF Aug. 1986 12 p
(Contract DAAG29-82-K-0029)
(AD-A172965; REPT-86-57; ARO-18560.28-EG) Avail: NTIS HC A02/MF A01 CSCL 21E

This report summarizes the results of an investigation of the solid particle dynamics and the resulting blade erosion through a helicopter engine with inlet particle separator. The particle trajectories are computed in the inlet separator which is characterized by considerable hub and tip contouring and radial variation in the swirling vane shape. The nonseparated particle trajectories are determined through the deswirling vanes and the five stage axial and one stage radial compressors. The impact data for a very large number of ingested particles is used to calculate the resulting blade surface erosion. The erosion pattern indicates the location of maximum blade erosion. In addition, the effect of high temperature on the erosion rate was determined in an erosion wind tunnel for AM355 steel and Al2O3 ceramics.

GRA

N87-15968# Rolls-Royce Ltd., Derby (England).
PROPULSION
J. R. SADLER 29 Jul. 1986 44 p
(PNR90321; ETN-87-98771) Avail: NTIS HC A03/MF A01

The principles and history of aircraft propulsion are recalled. The influence of fuel and maintenance economics and legal obligations is discussed. ESA

N87-15969# Rolls-Royce Ltd., Derby (England).
DESIGNING WITH TITANIUM
J. F. COPLIN 7 Jan. 1986 49 p Presented at an Institute of Metals Conference, 7 Jul. 1986
(PNR90325; ETN-87-98774) Avail: NTIS HC A03/MF A01

The use of titanium in aircraft engines, particularly compressors, is reviewed. Material properties, manufacturing, and developments are discussed. ESA

N87-15970# Rolls-Royce Ltd., Derby (England).
A STUDY OF PASSAGE FLOW THROUGH A CASCADE OF TURBINE BLADES USING IMAGE PLANE HOLOGRAPHIC INTERFEROMETRY
M. L. G. OLDFIELD (Oxford Univ., England), P. J. BRYANSTON-CROSS, J. H. NICHOLSON, and C. T. J. SCRIVENER 19 May 1986 12 p Sponsored by the UK Ministry of Defence Procurement Executive
(PNR90326; ETN-87-98775) Avail: NTIS HC A02/MF A01

Holographic interferograms showing the flow through two passages of a cascade of turbine rotor blades in an isentropic light piston tunnel with full-scale Reynolds numbers, Mach numbers, and gas-to-wall temperature ratios are presented. Double exposure absolute and differential image plane holograms of the complete flow field under a range of conditions were obtained. The isodensity contours predicted by a time marching throughflow calculation compare well with the positions of the interference fringe on the holograms. The intersections of these fringes with the blade surfaces give blade surface Mach numbers which agree well with those from surface pressure measurements. Wakes, shock waves, and the presence of upstream and side wall turbulence are all evident in the holograms. ESA

N87-15971 Department of the Air Force, Washington, D.C.
TEMPERATURE DETECTION SYSTEM FOR USE ON FILM COOLED TURBINE AIRFOILS Patent
ROBERT FREDERICK, inventor (to Air Force) 17 Jun. 1986 4 p Supersedes US-Patent-Appl-SN-729388
(AD-D012475; US-PATENT-4,595,298;
US-PATENT-APPL-SN-729388; US-PATENT-CLASS-374-144)
Avail: US Patent and Trademark Office CSCL 14B

This patent discloses an improved temperature detection system for use on film cooled turbine airfoils having a showerhead assembly with a series of parallel slots defined in the leading edge of an airfoil, each slot having a multiplicity of film flow ports exiting therefrom. A plurality of sensor assemblies are affixed to the airfoil showerhead and are couplable via electrodes to electronic sensing equipment for establishing the gas flow temperature. GRA

N87-15972 Department of the Air Force, Washington, D.C.
VARIABLE CYCLE ENGINE FOR HIGH ALTITUDE AIRCRAFT Patent
G. D. BREWER, inventor (to Air Force) 8 Jul. 1986 6 p Supersedes US-Patent-Appl-SN-698720
(AD-D012522; US-PATENT-4,598,543;
US-PATENT-APPL-SN-698720; US-PATENT-CLASS-60-39.161)
Avail: US Patent and Trademark Office CSCL 21E

A turboshaft engine is modified to be able to operate as a turbojet or a turboprop by the movement of an annular slide valve that directs gas flow between a high pressure turbine and a low pressure turbine. GRA

N87-15973# Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
AN ANALYTICAL STUDY OF ICING SIMILITUDE FOR AIRCRAFT ENGINE TESTING Final Report, Sep. 1985 - Jun. 1986
C. S. BARTLETT Oct. 1986 110 p Prepared in cooperation with AEDC
(AD-A173713; AEDC-TR-86-26; DOT/FAA/CT-86/35) Avail: NTIS HC A06/MF A01 CSCL 04B

An analytical study was conducted of the requirements for achieving similitude for icing as test conditions were varied. The application is aimed at engine icing tests conducted in ground spray rig facilities. The analysis considers the changes in the icing test conditions, including static temperature, static pressure, liquid water content, droplet size, and flow velocity, that are required to achieve similitude if any of the conditions are changed. The analysis uses a math model of icing scaling which has been validated by experimental data collected at the AEDC icing research tunnel. The requirements for similitude were analyzed for changes in both temperature and pressure. Expressions to describe the influence of test condition changes on the value of the scaling parameter were developed. The effect of icing caused by free-stream static temperature changes and temperature rise through a generic high-bypass turbofan engine was studied. The icing test points listed for compliance testing for aircraft icing certification under guidelines given in the FAA Advisory Circular (AC) 20-73 were used as test points for the analyses. GRA

N87-15974# General Electric Co., Binghamton, N.Y. Armament and Electrical Systems Dept.
PERMANENT MAGNET VARIABLE SPEED CONSTANT FREQUENCY POWER GENERATION SYSTEM Final Report, Aug. 1978 - Jun. 1984
G. P. KOERNER and E. U. SIDDIQUI Mar. 1986 161 p
(Contract F336125-78-C-2200)
(AD-A173959; AES-14070; AFWAL-TR-85-2112) Avail: NTIS HC A08/MF A01 CSCL 10B

The design, development, and aircraft installation of a 60-KVA permanent magnet starter-generator system is presented. The primary objective of this program was to advance the permanent magnet technology and demonstrate that a flexible, reliable, and low-cost starting means can be provided. The electrical system, developed under this program, obviates the use of large air ducts and complicated gearboxes, clutches, and torque converters. Eleven systems were fabricated and flight qualification was completed. The starting capability was demonstrated at Syracuse Air National Guard base and at the General Electric Engine facility in Lynn, Massachusetts. An A-10 aircraft was completely modified at Nellis Air Force base, and the permanent magnet starter-generator was installed. The planned flight test was deferred by Tactical Air Command and, thus, the aircraft was demodified and placed into regular operation. GRA

N87-16172# Joint Publications Research Service, Arlington, Va.
DISCOVERY DOUBLES JET ENGINE THRUST IN EXPERIMENTS
In its USSR Report: Engineering and Equipment p 58 13 Aug. 1986 Transl. into ENGLISH from Vechernyaya Moskva (Moscow, USSR), 20 Mar. 1986 p 1
Avail: NTIS HC A04/MF A01

A discovery in the field of mechanics is reported. The discovery increases the reactive force when atmospheric air is displaced by a fluctuating active jet. It is claimed that this phenomenon was previously unkown. The thrust horsepower of engines was increased by 2.0 to 2.5 times in experiments. This discovery makes it possible to heighten substantially the efficiency of jet engines, gas turbine units and other technology. E.R.

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A87-20383
INVARIANCE OF THE LATERAL DISTURBED MOTION OF VTOL AIRCRAFT WITH A VECTOR CONTROL SYSTEM [OB INVARIANTNOSTI BOKOVOGO VOZMUSHCHENNOGO DVIZHENIIA SVVP S VEKTORNOI SISTEMOI UPRAVLENIIA]
V. I. PENTIUKHOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 32-35. In Russian.

The principal properties of the lateral channels of a vector system for the control of the disturbed motion of VTOL aircraft are investigated for near-zero velocities. Conditions are determined under which the lateral channels of the vector control system are capable of ensuring the invariance of the angles of roll and yaw with respect to lateral wind gusts. V.L.

A87-20384
PARAMETRIC SYNTHESIS OF FLIGHT VEHICLE CONTROL IN THE CASE OF INDETERMINACY OF THE INITIAL CONDITIONS AND PERTURBATIONS [PARAMETRICHESKII SINTEZ UPRAVLENIIA LETATEL'NYMI APPARATAMI V USLOVIIAKH NEOPREDELENNOSTI NACHAL'NYKH USLOVII I VOZMUSHCHAIUSHCHIKH VOZDEISTVII]
R. T. SIRAZETDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 35-40. In Russian. refs

An algorithm is proposed for the synthesis of sets of trajectories for linear dynamic systems in the case of indeterminacy of the initial state and a perturbing action in a given parametrizable class. The control synthesis problem is treated as the main control problem which consists in selecting control system parameters in such a way as to satisfy given constraints on the quality criteria for the sets of trajectories. V.L.

A87-20404
A METHOD FOR SUPRESSING THE FLUTTER OF A TAIL UNIT WITH A NONBALANCED CONTROL SURFACE [O SPOSOBE PODAVLENIIA FLATTERA OPERENIIA S NESBALANSIROVANNYM RULEM]
A. V. STARIKOV and S. K. CHERNIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 91, 92. In Russian.

A method for suppressing flexural-rudder flutter is proposed which consists in shifting the hinge of the control surface of the tail unit relative to the stabilizer. Equations are presented which make it possible to evaluate the nature of tail unit oscillations for different values of the hinge displacement. For given stiffness values of a tail unit, it is always possible to select the shift of the control surface in such a way as to stabilize the structure against flexural-rudder flutter. V.L.

A87-20973
APPLICATION OF MODERN SYNTHESIS TO AIRCRAFT CONTROL - THREE CASE STUDIES
DAGFINN GANGSAAS, KEVIN R. BRUCE, JAMES D. BLIGHT, and UY-LOI LY (Boeing Co., Seattle, WA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-31, Nov. 1986, p. 995-1014. refs

The application of computer-aided synthesis techniques to the design of aircraft control laws is reviewed and illustrated with graphs, tables, and block diagrams. The case studies presented are an improved lateral autopilot for the B-767, a longitudinal control law for an advanced fuel-efficient transport aircraft, and a highly reliable backup system for the latter. The computer technique is shown to produce generally better control laws than classical methods, and at significantly reduced cost. T.K.

A87-22392#
ROBUST CONTROL OF AIRCRAFT REFUELING - A PRELIMINARY INVESTIGATION
DIANE V. DEWALT AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p.
(AIAA PAPER 87-0070)

A robust nonlinear control law is implemented for the system of two aircraft, a fighter and a tanker, during a refueling process. Robust nonlinear control ensures dynamic asymptotic stability of a system in the presence of large uncertainties in system parameters, plant dynamics, and external disturbances, whereas linear feedback control will only provide bounded input - bounded output stability. Robust nonlinear control is desirable for this system since it provides better transient behavior as well as asymptotic stability. Author

A87-22570*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
REAL-TIME COMPARISON OF X-29A FLIGHT DATA AND SIMULATION DATA
JOSEPH GERA (NASA, Flight Research Center, Edwards, CA), DOMINICK ANDRISANI, II (Purdue University, West Lafayette, IN), JEFFREY E. BAUER, and DAVID B. CRAWFORD AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p.
(AIAA PAPER 87-0344)

This paper presents a technique for comparing, in real time, the flight test time histories for X-29A aircraft with time histories computed from linearized mathematical models. Such a comparison allows the flight test personnel to verify that the aircraft is performing as predicted, to determine regions of nonlinear behavior, and to increase the rate of envelope expansion. The types of mathematical modeling and equipment required, the procedure used, and actual flight test results are discussed. Author

A87-22571#
PILOT/VEHICLE ANALYSIS OF THE LATERAL/VERTICAL CONTROL OF A TWIN-LIFT HELICOPTER CONFIGURATION
R. A. HESS (California, University, Davis) and P. M. TRAN AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0345)

The use of two helicopters in a single twin-lift configuration to carry heavy or oversized loads is a feasible means for increasing the productivity of rotary-wing vehicles. A stability and manual control analysis of a twin-lift configuration employing a load suspended from a rigid spreader bar is undertaken. The effect of system parameter variations upon open-loop stability characteristics is outlined. A two pilot manual control structure is formulated in which the pilot of the 'master' vehicle moves his helicopter in response to internally generated position commands. The pilot of the 'slave' vehicle interprets master helicopter translational motion as a position command to his own vehicle. The required pilot equalization in all the control loops is established and closed-loop performance is assessed through computer simulation. Author

A87-22572#
NONLINEAR FLYING QUALITIES - ONE APPROACH
C. F. SUCHOMEL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0347)

This paper describes the need for nonlinear flying quality metrics followed by a discussion of one approach to this problem. This analytic technique is under development in the Flight Control Division and uses truncated nonlinear Volterra series to solve the aircraft system of acceleration equations to obtain the system velocities. Numerical results are presented that illustrate the accuracy of this approach. The paper concludes with a description of how the Volterra series can be used to define nonlinear flying quality metrics analytically. Author

A87-22573#
LONGITUDINAL STABILITY ANALYSIS OF ELASTIC VEHICLES
SHILU CHEN, XINGJIAN CHEN, HENGYUAN YAN, and XIUFANG HUO (Northwestern Polytechnical University, Xian, People's Republic of China) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 5 p. Translation. Previously cited in issue 08, p. 995, Accession no. A86-22310. refs
(AIAA PAPER 87-0348)

A87-22574#
ON THE CONTROL OF AUTO-ROTATIONAL CHARACTERISTICS OF LIGHT AIRPLANE FUSELAGES
B. N. PAMADI, A. RAHMAN (Indian Institute of Technology, Bombay, India), and V. JAMBUNATHAN AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0349)

Single-degree-of-freedom, free-to-roll, autorotational tests in a low-speed wind tunnel are conducted to explore the effect of windward strakes on the autorotational characteristics of typical light-airplane fuselage models. The results indicate that the autorotational speeds are very sensitive to strake height and location. With this technique, it is demonstrated that a large degree of control can be obtained over the autorotational behavior of such fuselages. Author

A87-22920
CONTROL EVOLUTION AND THE A320
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 130, Nov. 1, 1986, p. 28, 29.

Automated gust-load alleviation (GLA), high-lift wing configuration and electronic fault detection (EFD) systems on the A320 are described. Accelerometers were installed instead of gust vanes for compatibility with the digital control system. Vertical loading eliminated by the system permitted use of less material in the wing, particularly on the top side, because of the automated aileron and output spoiler movement in response to loading. The wings have a 25 deg sweep and a 9.4:1 aspect ratio, a slotted slat for the leading edge and a single-element flap that can be deflected 40 deg for the trailing edge. The distributed EFD system is linked to a centralized fault display system and is intended to detect component problems between scheduled maintenance inspections. The Bite expert system which is under development to provide the maintenance recommendations was, as of late 1986, delivering 65-75 percent accuracy. M.S.K.

A87-23078
MODELING, DESIGN, AND ANALYSIS OF A DISCRETE AUTOPILOT AND THE AIR VEHICLE IT CONTROLS
GEORGE S. DULEBA (Boeing Computer Services Co., Engineering Technology Applications Div., Seattle, WA) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 859-863.

The overall effort of building a computer model for a missile flight control system and performing a variety of compute-intensive design and analysis tasks is efficiently accomplished by the simulation engineer using EASY5 on a CRAY supercomputer. This paper presents an example of a 6-degree-of-freedom rigid-body air vehicle and its two-axis digital autopilot. The example illustrates the model building approach and the application of the Parameter Optimization feature to the design of the two-axis autopilot. This design feature maximizes vehicle flight performance, while also satisfying a large number of system stability constraints. Verification of the resulting design is accomplished using nonlinear time-history analysis and linear stability analysis techniques. Author

N87-15233 Ohio State Univ., Columbus.
FORMULATION AND MINIMALITY OF NONLINEAR DISCRETE TIME CONTROL SYSTEMS Ph.D. Thesis
CHARLES EDWARD HALL, JR. 1986 107 p
Avail: Univ. Microfilms Order No. DA8618781

At the Aeronautical and Astronautical Research Laboratory of the Ohio State University, experimental investigations of unsteady aerodynamics of airfoils required an apparatus to vary the airflow angle of attack as an arbitrary function of time. A pneumatically driven system was designed, necessitating a nonlinear control system. Here, the digital control methodologies developed to assist in the design are presented. The formulation of the nonlinear discrete time control system from a nonlinear continuous time control system is presented in two different methods; an exact formulation for analytic continuous time systems possessing a finite lengthed Volterra series, and an approximation method based on the Runge-Kutta integration technique. The criteria for nonlinear discrete time observability is derived from the Implicit Function Theorem. The criteria for controllability is based on the geometric interpretation of the Lie algebra used in continuous time system theory. It is then shown that if the continuous time system is both controllable and observable and the discrete time system is observable, then the discrete time system is also controllable.
Dissert. Abstr.

N87-15234*# Calspan Advanced Technology Center, Buffalo, N.Y.
FLARED LANDING APPROACH FLYING QUALITIES. VOLUME 1: EXPERIMENT DESIGN AND ANALYSIS Final Report, Apr. 1985 - Sep. 1986
NORMAN C. WEINGARTEN, CHARLES J. BERTHE, JR., EDMUND G. RYNASKI, and SHAHAN K. SARRAFIAN Dec. 1986 200 p
Sponsored by NASA
(Contract NASA ORDER L-85272-B; F33615-83-C-3603)
(NASA-CR-178188-VOL-1; NAS 1.26:178188-VOL-1; REPT-7205-13-VOL-1) Avail: NTIS HC A09/MF A01 CSCL 01C

An inflight research study was conducted utilizing the USAF Total Inflight Simulator (TIFS) to investigate longitudinal flying qualities for the flared landing approach phase of flight. The purpose of the experiment was to generate a consistent set of data for: (1) determining what kind of commanded response the pilot prefers in order to flare and land an airplane with precision, and (2) refining a time history criterion that took into account all the necessary variables and their characteristics that would accurately predict flying qualities. The result of the first part provides guidelines to the flight control system designer, using MIL-F-8785-(C) as a guide, that yield the dynamic behavior pilots perfer in flared landings. The results of the second part provides the flying qualities engineer with a newly derived flying qualities predictive tool which appears to be highly accurate. This time domain predictive flying qualities criterion was applied to the flight data as well as six previous flying qualities studies, and the results indicate that the criterion predicted the flying qualities level 81% of the time and the Cooper-Harper pilot rating, within + or - 1, 60% of the time.
Author

N87-15936# Joint Publications Research Service, Arlington, Va.
OPTICAL TRANSDUCER: STOL AIRCRAFT
In its Japan report: Science and Technology (JPRS-JST-87-001) p 3-5 7 Jan. 1987 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Jul. 1986 p 2-3
Avail: NTIS HC A06/MF A01

Research on the FBL (fly by light) is being conducted as a part of the research on future technology for STOL aircraft. This FBL is used to optically transmit signals emitted from control systems. The main features of the experimental optical transducer are described. Environmental resistance tests, functional tests, and performance tests are scheduled to be conducted for the optical transducer unit by using a rig testing unit and an experimental aircraft.
B.G.

N87-15975*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PREDICTION OF WING AEROELASTIC EFFECTS ON AIRCRAFT LIFT AND PITCHING MOMENT CHARACTERISTICS
CLINTON V. ECKSTROM Oct. 1986 19 p Presented at the AGARD Specialists Meeting on Static Aeroelastic Effects on High Performance Aircraft, Athens, Greece, 1-2 Oct. 1986
(NASA-TM-89060; NAS 1.15:89060) Avail: NTIS HC A02/MF A01 CSCL 01C

The distribution of flight loads on an aircraft structure determine the lift and pitching moment characteristics of the aircraft. When the load distribution changes due to the aeroelastic response of the structure, the lift and pitching moment characteristics also change. An estimate of the effect of aeroelasticity on stability and control characteristics is often required for the development of aircraft simulation models of evaluation of flight characteristics. This presentation outlines a procedure for incorporating calculated linear aeroelastic effects into measured nonlinear lift and pitching moment data from wind tunnel tests. Results are presented which were obtained from applying this procedure to data for an aircraft with a very flexible transport type research wing. The procedure described is generally applicable to all types of aircraft.
Author

N87-15976*# Calspan Advanced Technology Center, Buffalo, N.Y.
FLARED LANDING APPROACH FLYING QUALITIES. VOLUME 2: APPENDICES Final Report, Apr. 1985 - Sep. 1986
NORMAN C. WEINGARTEN, CHARLES J. BERTHE, JR., EDMUND G. RYNASKI, and SHAHAN K. SARRAFIAN Dec. 1986 456 p
(Contract NASA ORDER L-85272-B; F33615-83-C-3603)
(NASA-CR-178188-VOL-2; REPT-7205-13-VOL-2; NAS 1.26:178188-VOL-2) Avail: NTIS HC A20/MF A01 CSCL 01C

An in-flight research study was conducted utilizing the USAF/Total In-Flight Simulator (TIFS) to investigate longitudinal flying qualities for the flared landing approach phase of flight. A consistent set of data were generated for: determining what kind of command response the pilot prefers/requires in order to flare and land an aircraft with precision, and refining a time history criterion that took into account all the necessary variables and the characteristics that would accurately predict flying qualities. Seven evaluation pilots participated representing NASA Langley, NASA Dryden, Calspan, Boeing, Lockheed, and DFVLR (Braunschweig, Germany). The results of the first part of the study provide guidelines to the flight control system designer, using MIL-F-8785-(C) as a guide, that yield the dynamic behavior pilots prefer in flared landings. The results of the second part provide the flying qualities engineer with a derived flying qualities predictive tool which appears to be highly accurate. This time-domain predictive flying qualities criterion was applied to the flight data as well as six previous flying qualities studies, and the results indicate that the criterion predicted the flying qualities level 81% of the time and the Cooper-Harper pilot rating, within + or - 1%, 60% of the time.
Author

N87-15977*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ESTIMATION OF BIAS ERRORS IN MEASURED AIRPLANE RESPONSES USING MAXIMUM LIKELIHOOD METHOD
VLADIASLAV KLEIN and DAN R. MORGAN Jan. 1987 34 p
(NASA-TM-89059; NAS 1.15:89059) Avail: NTIS HC A03/MF A01 CSCL 01C

A maximum likelihood method is used for estimation of unknown bias errors in measured airplane responses. The mathematical model of an airplane is represented by six-degrees-of-freedom kinematic equations. In these equations the input variables are replaced by their measured values which are assumed to be without random errors. The resulting algorithm is verified with a simulation and flight test data. The maximum likelihood estimates from in-flight measured data are compared with those obtained by using a nonlinear-fixed-interval-smoother and an extended Kalmar filter.
Author

N87-15978# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MODELLING OF RIGID-BODY AND ELASTIC AIRCRAFT DYNAMICS FOR FLIGHT CONTROL DEVELOPMENT M.S. Thesis
JOHN J. CERRA, II Jun. 1986 118 p
(AD-A172423; AFIT/GAE/AA-86J-2) Avail: NTIS HC A06/MF A01 CSCL 01C

The purpose of this effort was to provide a method of developing a linear model of an elastic aircraft. The model provides the capability to analyze the coupling between the rigid and elastic motion of the aircraft. The method developed in this effort obtains stability derivatives directly from unsteady aerodynamic forces. This results in a state space model whose states are just the normal aircraft states and rates, the structural coordinates and rates, and the control surface positions and rates. Using a representation of the YF-17 wind tunnel flutter model, it was demonstrated that the methodology developed predicted the required dynamics to make this a viable method of modelling rigid body and flutter behavior of the model. Flutter control laws were designed for motion about an equilibrium condition represented by a velocity 20% above the flutter velocity. Both classical and modern techniques yielded acceptable control laws. The control laws were also analyzed at off design conditions to check robustness. GRA

N87-15979# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA AERONAUTICA ET ASTRONAUTICA SINICA (SELECTED ARTICLES)
ZHONGJI CHEN, HONGYUE ZHANG, ZHIMING XIN, SHICUM WANG, and LONGDE HE 10 Oct. 1986 51 p Transl. into ENGLISH from Hang Kong Xuebao (China), v. 6, no. 6, Dec. 1985 p 513-520; 521-529; 585-589
(AD-A173610; FTD-ID(RS)T-0834-86) Avail: NTIS HC A04/MF A01 CSCL 01C

Topics addressed include: adaptive control techniques; robustness (mathematics); helicopter stability and controllability; hingeless rotors; three-dimensional unsteady flow; delta wings; angle of attack; computational fluid dynamics; and rotor-induced blade flapping. B.G.

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

A87-19651
ON GROUND CALIBRATION OF A PUSHBROOM SCANNER
C. SMORENBURG and A. L. G. VAN VALKENBURG (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Technisch Physische Dienst TNO, Delft, Netherlands) IN: Instrumentation for optical remote sensing from space; Proceedings of the Meeting, Cannes, France, November 27-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 46-53.

To perform in the laboratory the final calibration of a pushbroom scanner a flexible test arrangement has been developed. Herewith radiometric and geometric calibration can be performed to a CCD based multispectral scanner. With the same arrangement spectral calibration and a simple check of instrumental sensitivity to polarization and straylight are possible. For proper understanding of the calibration procedure both the scanner and the test arrangement are described. Author

A87-19700
SIMULATION OF FUTURE THERMAL IMAGERS
M. BUSSON (Centre d'Electronique de l'Armement, Bruz, France) IN: Infrared technology and applications; Proceedings of the Meeting, Cannes, France, November 26-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 405-412.

Computer simulation has been used during the specification phase for new thermal imagers. Thanks to computer simulation, the human operator, who will be the user of the system, has also been taken into account in the assessment. This presentation describes the method applied, supported with some experimental results concerning the technological choices as regards camera focal planes. In this example, the approach can easily be extrapolated to the much broader scope which this tool might well have. Author

A87-20352
THE AIRPORT PASSENGER TERMINAL
WALTER HART New York, Wiley-Interscience, 1985, 260 p.

Airport terminal planning and design is discussed with emphasis placed on conceptual planning, forecasting, space calculations, and design solutions. The terminal complex is discussed in the context of the airport planning and design process since the effectiveness of passenger transport manifests itself in the apron terminal area, where the movements of aircraft, people, and ground transportation vehicles must efficiently interact to achieve the necessary and desired levels of productivity. Attention is given to: (1) creative planning and design; (2) the determination, sizing, and arrangement of the functional elements in one comprehensive plan; and (3) incorporating expansion capabilities and flexibility required to accommodate changes in traffic characteristics. K.K.

A87-20679
ON WINGS INTO SPACE
CURTIS PEEBLES Spaceflight (ISSN 0038-6340), vol. 28, June 1986, p. 276-280.

The development of the Ames-Dryden Flight Research Facility is discussed. Factors which contributed to the expansion of the facility, and its capabilities are described. Consideration is given to aircraft and rocket development and flight testing at the facility and the use of the facility for the Space Shuttle. I.F.

A87-20936
FIRST MOBILE ARRESTING SYSTEMS NOW BEING DEPLOYED
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Oct. 1986, p. 22-26.

The first operational arresting gear for the accommodation of returning tactical aircraft on bomb-damaged runways, designated the Mobile Aircraft Arresting System (MAAS), has been delivered to the U.S. Air Force's Ramstein Air Base, in West Germany for use by A-7, F-4, F-15, and F-16 aircraft. MAAS furnished a nominal 990 ft of runout for 1.25-in. cable and 8.5-in. wide nylon woven tape, and is deployed by a 4-wheel trailer that can be anchored in soil, concrete, or asphalt, depending on landing site conditions. Two water-cooled brake system asemblies are employed. O.C.

A87-21002#
AN APPLICATION OF AP-FORTRAN - A RESEARCH SIMULATOR [PRESENTATION D'UNE APPLICATION AP-FORTRAN - SIMULATEUR DE RECHERCHE]
CLAIRE MICHELON (ONERA, Chatillon-sous-Bagneux, France) (GUP-FPS, Journees, Paris, France, May 13-15, 1986) ONERA, TP, no. 1986-69, 1986, 29 p. In French.
(ONERA, TP NO. 1986-69)

The hardware and software of the ONERA Laboratory for Flight Mechanics fixed base flight simulator which accommodates man-in-the-loop trials are described. Driven by a host SEL 32 computer, the simulator has a cockpit with a look-forward simulation, a head-down instrument display panel, and an engineer's station. The system software, written in AP-FORTRAN, includes real-time data collection, analysis and display capabilities,

and the capacity for tracking the temporal evolution of events occurring in the simulator. The simulator is mainly used for developing control laws for transport aircraft in the takeoff and landing flight phases. M.S.K.

A87-21056#
TESTING CAPABILITIES OFFERED BY THE ONERA HYDRODYNAMIC FLOW VISUALIZATION TUNNELS FOR AERONAUTICAL AND NAVAL APPLICATIONS [POSSIBILITES D'ESSAI OFFERTES PAR LES TUNNELS HYDRODYNAMIQUES A VISUALISATION DE L'ONERA DANS LES DOMAINES AERONAUTIQUE ET NAVAL]
H. WERLE (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium, Monterey, CA, Oct. 20-24, 1986) ONERA, TP, no. 1986-155, 1986, 17 p. In French. refs
(ONERA, TP NO. 1986-155)

The techniques and apparatus developed by ONERA for plane, axisymmetric and three-dimensional flow visualization studies are described. The Chatillon laboratories have three open circuit hydrodynamic tunnels in vertical orientations, the flows being driven by gravity. Scale-models, mounting configurations, and mount parasitic drag reduction methods are summarized for high performance aircraft, helicopter and submarine model tests. High speed photography, dye injection, and bubble injection procedures employed for flow visualization are outlined and photographs are reproduced of sample flow visualization results. M.S.K.

A87-21070#
RECENT PROGRESS IN THE MEASUREMENT OF THE DRAG COEFFICIENT OF MODELS OF TRANSPORT AIRCRAFT IN A WIND TUNNEL [PROGRES RECENTS DANS LA MESURE EN SOUFFLERIE DU COEFFICIENT DE TRAINEE DE MAQUETTES D'AVION DE TRANSPORT]
C. ARMAND, P. HUGOUVIEUX, and R. SELVAGGINI ONERA, TP, no. 1986-170, 1986, 47 p. In French.
(ONERA, TP NO. 1986-170)

Techniques and apparatus employed by ONERA researchers at Modane to obtain an accuracy of 0.0001 in drag measurements on scale models of transport aircraft are described. Emphasis is placed on cruise flight configurations for, the Airbus, and on the computational methods applied to correct the data for scale models to account for wind tunnel effects, as opposed to aircraft in actual flight. Model design, the mounts used, calibration of the balances and the angle of attack, and the data acquisition and treatment systems are summarized. Methods used to offset the thermal, friction, wall and support effects on the flowfield are discussed. M.S.K.

A87-21080#
THE INTERFERENCE OF THE MODEL SUPPORT MAST WITH MEASUREMENTS OF THE LONGITUDINAL AND LATERAL AERODYNAMIC COEFFICIENTS [INTERACTION D'UN MAT SUPPORT DE MAQUETTE SUR LES MESURES DES COEFFICIENTS AERODYNAMIQUES LONGITUDINAUX ET LATERAUX]
C. VAN DE KREEKE (ONERA, Chatillon-sous-Bagneux, France), J. VERRIERE (Aerospatiale, Paris, France), and G. QUEMARD (Toulouse, Centre d'Essais Aeronautique, France) ONERA, TP, no. 1986-181, 1986, 28 p. In French.
(ONERA, TP NO. 1986-181)

The effects the single bottom support masts used in the ONERA S1 and S4 wind tunnels have on aerodynamic data collected with scale model aircraft were examined experimentally and analytically. Systematic studies were performed on the flow characteristics around different diameters for the mounts. Scaling methods used to make data from one wind tunnel correspond to data from the other are described. Airbus 320 models were introduced into the tests and mast-body flow interactions were observed. A summary is presented of restrictions on the mast diameters, relative to cylindrical model diameters, which will minimize the effects the masts have on longitudinal and lateral aerodynamic stability data. M.S.K.

A87-21532*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONSTRUCTION OF A 2- BY 2-FOOT TRANSONIC ADAPTIVE-WALL TEST SECTION AT THE NASA AMES RESEARCH CENTER
DANIEL G. MORGAN and GEORGE LEE (NASA, Ames Research Center, Moffett Field, CA) AIAA and ASME, Joint Fluid Mechanics, Plasma Dynamics and Lasers Conference, 4th, Atlanta, GA, May 12-14, 1986. 14 p. refs
(AIAA PAPER 86-1089)

The development of a new production-size, two-dimensional, adaptive-wall test section with ventilated walls at the NASA Ames Research Center is described. The new facility incorporates rapid closed-loop operation, computer/sensor integration, and on-line interference assessment and wall corrections. Air flow through the test section is controlled by a series of plenum compartments and three-way slide vales. A fast-scan laser velocimeter was built to measure velocity boundary conditions for the interference assessment scheme. A 15.2-cm- (6.0-in.-) chord NACA 0012 airfoil model will be used in the first experiments during calibration of the facility. Author

A87-22371#
NAVIER-STOKES SIMULATION OF SIDE-WALL EFFECT OF TWO-DIMENSIONAL TRANSONIC WIND TUNNEL
KUNIO KUWAHARA (Tokyo, University, Japan) and SHIGERU OBAYASHI AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0037)

A transonic wind tunnel test of a flow around an NACA0012 airfoil is simulated by using both two-dimensional and three-dimensional Navier-Stokes codes. The effect of the side wall is focused on. The results revealed strong three-dimensionality introduced by the side-wall effect. To simulate the flow fields, 1.5 million grid points were used on a supercomputer VP200 having 256 MBytes main memory. The computation took about 25 hours for one case. Author

A87-22380*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A TRANSITION DETECTION STUDY USING A CRYOGENIC HOT FILM SYSTEM IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
C. B. JOHNSON, D. L. CARRAWAY, P. C. STAINBACK (NASA, Langley Research Center, Hampton, VA), and M. F. FANCHER (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 23 p. refs
(AIAA PAPER 87-0049)

A transition detection study was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT) using a specialized hot film system designed specifically for use in cryogenic wind tunnels. The quantitative transition location data obtained at near cryogenic conditions, 360 deg R (200K) represents the first definitive transition Reynolds numbers obtained in a cryogenic wind tunnel. The model was tested at both adiabatic and nonadiabatic wall conditions with a wall-to-total temperature ratio as low as 0.47. The test results indicated an improved technique for hot-film installation and a modified data acquisition system would allow the on-line determination of the location of boundary layer transition in cryogenic wind tunnels, such as the U.S. National Transonic Facility. Author

A87-22463#
OBSERVATIONS ON THE DEVELOPMENT OF A NATURAL REFRIGERATION ICING WIND TUNNEL
J. J. IDZOREK (FluiDyne Engineering Corp., Minneapolis, MN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 30 p. refs
(AIAA PAPER 87-0175)

Observations are presented on a newly developed icing test facility. This induced flow wind tunnel is unique, both in its potential M 0.8 capability and the use of natural refrigeration to satisfy the cold air requirement. The facility calibration and its various

components are described. Initial icing tests to ascertain the accretion of ice on 5.25 to 21-inch chord NACA 0002 airfoils are presented and discussed. The facility has demonstrated its ability to create the conditions necessary for the observation and measurement of icing. The tests will be useful in determining the performance penalties due to icing as well as to investigate deicing and antiicing techniques. Author

A87-22506#
THE INFLUENCE OF SUPPORT OSCILLATION IN DYNAMIC STABILITY TESTS
MARTIN E. BEYERS (National Research Council of Canada, Ottawa) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0243)

A tractable but quite general analysis of the influence of support oscillation in oscillatory wind tunnel testing is presented. This is an extension of a recent analysis of sting plunging in the pitch-oscillation mode. It is shown that the sting plunging correction is equivalent to an aerodynamic axis transformation from the inertial rotation center. The basic approach is free of simplifying assumptions beyond those implicit in the transformation equations and can be extended to any measurement degree of freedom. The only requirement is for appropriate measurements of the location of the axis of rotation. Author

A87-22516#
ROTATING ARMS APPLIED TO STUDIES OF SINGLE ANGULAR DROP IMPACTS
A. FEO (Instituto Nacional de Tecnica Aeroespacial, Madrid, Spain) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0257)

This paper describes a possible way to obtain experimental information for single angular drop collisions by the use of a rotating arm supplemented by a drop generation system and a single picture high-speed photography set-up. Rotating arm, model and drop conditions needed to produce suitable experiments that can be applied to the understanding of rain effects on the aerodynamics of airfoils are reviewed. Some results are obtained in a low power rotating arm facility by sequences of single high-speed photographs. The conditions in which the experiments have been performed are also included. Author

A87-22541#
A WAKE BLOCKAGE CORRECTION METHOD FOR SMALL SUBSONIC WIND TUNNELS
CLAY Q. PASS (General Dynamics Corp., Fort Worth, TX) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0294)

A wake blockage correction method has been developed for use in small subsonic wind tunnels. Work on the method was initiated due to the extensive blockage effects encountered while testing preliminary design models in the General Dynamics 14 by 14 inch open circuit tunnel. A test program was conducted where base pressure data were measured on a series of non-lifting flat plates in order to confirm the theoretical basis of the method. Also, force and moment data were measured on a series of lifting wing plates and used in the development of empirical factors in the final correction equation. The resulting correction method incorporates the theoretical approach formulated by Maskell (Great Britain) but utilizes empirical terms adopted specifically for semispan tests of models with high blockage ratios. Results presented from tests of wings with blockage ratios up to 29 percent indicated the method will approximately double the range of blockage ratios where the Maskell method is considered valid. The method has shown to remain effective for a wide variety of wing planforms and demonstrates that reliable wake blockage corrections may be obtained by relatively simple and inexpensive means. Author

A87-23066
MODULAR SIMULATION FACILITY DESIGN
MARK A. WILSON (Martin Marietta Corp., Orlando, FL) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 541-546.

The modular simulation-facility concept has many advantages over more conventional 'evolutionary' designs, which suffer either from a build-it-as-you-need-it philosophy that gives short shrift to fault-isolation, interface, and maintenance, or from excessively specific designs that make adaptation for more general uses difficult. In modular design, separation of functions allows rapid fault isolation. Line replaceable units (LRUs) within the subsystems allow maximum uptime. Reliance on 'store-bought' hardware reduces engineering development work and improves access to spares. Standardized interfaces and formally defined functions make it easier to implement existing and new hardware and software into new simulations. System architecture can be easily tailored to specific simulations. Subsystems and subsystem components can be upgraded with little or no impact on other subsystems. Flight hardware can be integrated with the simulation cockpits made compatible with MIL-STD-1553. These advantages enhance the flexibility of the simulation facility while reducing operating costs. Author

A87-23261#
FACILITIES AND PROCEDURES FOR TEST AND EVALUATION OF AIRBORNE INFRARED IMAGING SYSTEMS AT EDWARDS AIR FORCE BASE
JOHN L. MINOR and STEVEN E. SHIMER (USAF, Flight Test Center, Edwards AFB, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 10 p. refs
(AIAA PAPER 86-9816)

Consideration is given to the techniques and facilities used to evaluate in-flight resolution and sensitivity of airborne FLIR systems. The large and small IR target boards, targets for laser operation, and vehicular targets of the Air Force Flight Test Center (AFFTC) at Edwards Air Force Base are described. For in-flight resolution and sensitivity evaluation, target and background thermal profiles, aircraft slant range to target, and atmospheric attenuation of the IR energy radiated from the target and background to the airborne FLIR, and FLIR video data are monitored and recorded. The use of test ranges to evaluate the FLIR is examined. The procedures for determining minimum resolvable and detectable temperature difference of an airborne FLIR sensor are discussed. Plans for upgrading the AFFTC's IR test capability are proposed. I.F.

N87-15235*# National Aeronautics and Space Administration, Washington, D.C.
PROCEDURE FOR COMPUTING TRANSONIC FLOWS FOR CONTROL OF ADAPTIVE WIND TUNNELS Ph.D. Thesis - Technischen Univ., Mar. 1986
RAINER REBSTOCK Jan. 1987 110 p Transl. into ENGLISH of German Thesis Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88530; NAS 1.15:88530) Avail: NTIS HC A06/MF A01 CSCL 14B

Numerical methods are developed for control of three dimensional adaptive test sections. The physical properties of the design problem occurring in the external field computation are analyzed, and a design procedure suited for solution of the problem is worked out. To do this, the desired wall shape is determined by stepwise modification of an initial contour. The necessary changes in geometry are determined with the aid of a panel procedure, or, with incident flow near the sonic range, with a TSP procedure. Author

N87-15236*# National Aeronautics and Space Administration, Washington, D.C.
DIRECT CALCULATION OF WALL INTERFERENCES AND WALL ADAPTATION FOR TWO-DIMENSIONAL FLOW IN WIND TUNNELS WITH CLOSED WALLS
JUERGEN AMECKE Dec. 1986 94 p Transl. into ENGLISH of "Direkte Berechnung von Wandinterferenzen un Wandadaption bei Zweidimensionaler Stroemung in Windkanaelen mit Geschlossenen Waenden" rept. DFVLR, Goettingen, West Germany, Nov. 1985 Original language document was announced as N86-28065 Sponsored by NASA
(NASA-TM-88523; NAS 1.15:88523) Avail: NTIS HC A05/MF A01 CSCL 14B

A method for the direct calculation of the wall induced interference velocity in two dimensional flow based on Cauchy's integral formula was derived. This one-step method allows the calculation of the residual corrections and the required wall adaptation for interference-free flow starting from the wall pressure distribution without any model representation. Demonstrated applications are given. Author

N87-15237*# National Aeronautics and Space Administration, Washington, D.C.
INVESTIGATION OF THE COMPONENTS OF THE NAL HIGH REYNOLDS NUMBER TWO-DIMENSIONAL WIND TUNNEL. PART 4: DESIGN, CONSTRUCTION AND PERFORMANCE OF THE EXHAUST SILENCER
S. SAKAKIBARA, H. MIWA, S. KAYABA, and M. SATO Sep. 1986 51 p Transl. into ENGLISH of rept. TR-606 National Aerospace Lab., Japan, Apr. 1980 Original language document was announced as N81-71756 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88513; NAS 1.15:88513; TR-606-PT-4) Avail: NTIS HC A04/MF A01 CSCL 14B

Presented is a description of the design construction and performance of the exhaust silencer for the NAL high Reynolds number two-dimensional transonic blow down wind tunnel, which was completed in October 1979. The silencer is a two-storied construction made of reinforced concrete, 40 m. long, 10 m. wide and 19 m. high and entirely enclosed by thick concrete walls. The upstream part of the first story, particularly, is covered with double walls, the thickness of the two walls being 0.3 m. (inner wall) and 0.2 m. (outer wall), respectively. A noise reduction system using three kinds of parallel baffles and two kinds of lined bends is adopted for the wind tunnel exhaust noise. Author

N87-15238# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
FACILITIES TECHNOLOGY APPLICATION TESTS: FUEL-RESISTANT PAVEMENT SEALERS Final Report
JAMES E. SHOENBERGER and ELTON R. BROWN Aug. 1986 37 p
(AD-A171473; WES-MP-GL-86-19) Avail: NTIS HC A03/MF A01 CSCL 11A

This report details equipment, personnel, and material requirements as well as procedures used to demonstrate the application of fuel-resistant pavement sealers to asphaltic concrete airfield pavements. The demonstrations took place at Ft. Rucker and Ft. Belvoir. These locations each have asphalt pavements which are continually damaged by fuel spillage. Five sealers were placed at each location. GRA

N87-15981# Pailen-Johnson Associates, Inc., Vienna, Va.
AIRPORT PAVEMENT LOAD ANALYSIS Final Report
STEPHEN HALL 2 Sep. 1986 131 p
(Contract DTFA01-84-Y-01052)
(DOT/FAA/PM-86/36) Avail: NTIS HC A07/MF A01

The underlying theory and assumptions used in developing microcomputer software to determine and model the cumulative load distribution across any given airport pavement as a function of aircraft type and usage of the pavement are described. Author

N87-15982# Office of Naval Research, London (England).
AERODYNAMICS RESEARCH AND DEVELOPMENT AT THE ROYAL AIRCRAFT ESTABLISHMENT (RAE), FARNBOROUGH IN THE UNITED KINGDOM
L. L. COBURN 9 Jul. 1986 9 p
(AD-A171837; ONRL-R-5-86) Avail: NTIS HC A02/MF A01 CSCL 20D

This report is a survey of the organization and division of functions of the RAE research and development. It includes a summary that compares the UK MoD research establishments with the US Navy laboratories. GRA

N87-15985# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON FLIGHT SIMULATION
ANTHONY M. COOK (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.) Oct. 1986 14 p Symposium held in Cambridge, England, 30 Sep. - 3 Oct. 1985
(AGARD-AR-234; ISBN-92-835-0399-6) Avail: NTIS HC A02/MF A01

In recent years, important advances were made in technology both for ground-based and in-flight simulators. There was equally a broadening of the use of flight simulators for research, development, and training purposes. An up-to-date description of the state-of-the-art of technology and engineering was provided for both ground-based and in-flight simulators and their respective roles were placed in context within the aerospace scene. Author

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

A87-20262#
BOUNDARY-LAYER EFFECTS IN COMPOSITE LAMINATES
CHIEN-CHANG LIN (National Chunghsing University, Taichung, Republic of China) National Science Council, Proceedings, Part A: Physical Science and Engineering (ISSN 0255-6588), vol. 10, July 1986, p. 281-289. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-73-0401-E005-01)

This paper presents a theoretical study on the material eigenvalues, the stress singularity of free/edges, and the boundary-layer thermal stresses in both cross-ply laminates of graphite composites. It is shown that the singular strength of free-edge stress depends on the material properties of the two adjacent layers and the ply/orientations, and the cross-ply laminate has the strongest stress singularity. Author

A87-20574
APPLICATIONS OF COMPOSITES IN COMMERCIAL AIRCRAFT ABOUND
JEANNE M. ANGLIN (Boeing Commercial Airplane Co., Seattle, WA) ICAO Bulletin, vol. 41, Aug. 1986, p. 14-17.

An evaluation is made of the state-of-the-art in advanced composite materials components for airliner applications, with attention to those component design and fabrication concepts that most effectively optimize mass characteristics and reduce costs. The reinforcements of choice to date in organic polymer resin composites have been aramid, high strength glass, and carbon fibers, in either unidirectional prepreg tape or fabric forms; of these, the tape is more easily tailored to match structural load requirements and is lower in cost than fabrics. Attention is given

to such typical applications as empenage structures and control surface panels. O.C.

A87-20575
FUTURE BRIGHT FOR COMPOSITES USE IN GENERAL AVIATION
JAMES B. ABBIT (Avtek Corp., Camarillo, CA) ICAO Bulletin, vol. 41, Aug. 1986, p. 19-21.

The Avtek 400 general aviation twin-turboprop appears to be the first virtually all-composite (72 percent) primary structure aircraft to enter production. Extensive use is made of Nomex aramid honeycomb core/Kevlar-reinforced surface panel sandwich structures. Attention is presently given to the structure panel molding and bonding methods; there is a total of only 51 molded composite parts in the canard configuration's primary and secondary structures. O.C.

A87-22407*# Vigyan Research Associates, Inc., Hampton, Va.
NUMERICAL STUDY OF FINITE-RATE SUPERSONIC COMBUSTION USING PARABOLIZED EQUATIONS
T. CHITSOMBOON (Vigyan Research Associates, Inc., Hampton, VA), A. KUMAR (NASA, Langley Research Center, Hampton, VA), and S. N. TIWARI (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract NAG1-423)
(AIAA PAPER 87-0088)

A set of partial differential equations, describing the two-dimensional supersonic chemically-reacting flow of the hydrogen-air system, is formulated such that the equations are parabolic in the streamwise direction. A fully-implicit fully-coupled finite-difference algorithm is used to develop a computer code which solves the governing equations by marching in the streamwise direction. The combustion process is modeled by a two-step finite-rate chemistry whereas turbulence is simulated by an algebraic turbulence model. Results of two calculations of internal supersonic reacting flow show fairly good agreement with the results obtained by the more costly full Navier-Stokes procedure. Author

A87-22656#
FLAME STABILIZATION USING LARGE FLAMEHOLDERS OF IRREGULAR SHAPE
A. H. LEFEBVRE (Purdue University, West Lafayette, IN) and R. M. STWALLEY, III AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0469)

Measurements of blowoff velocity and drag coefficient are carried out on various two-dimensional flameholders, including flat plates and single- and double-sided vee-gutters. The vee-gutters are tested with and without slots cut in their trailing edges. The flat plates are tested at various inclinations to the flow stream, with cutouts in the leading edge, or trailing edge, or both. The test program covers wide ranges of effective pressure ratio obtained using the water injection technique, and it also includes variations in the size, blockage, and geometry of the flameholders. The results show that flameholder size is the most important parameter in determining aerodynamic blockage and that base-shape modifications play only a minor role. However, base-shape modifications do have a significant effect on flame stability. In particular, the random removal of material from a regular bluff body always has an adverse effect on its flameholder properties. Author

A87-23259*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPPOSED JET BURNER STUDIES OF SILANE-METHANE, SILANE-HYDROGEN, AND HYDROGEN DIFFUSION FLAMES WITH AIR
G. L. PELLETT, ROSEMARY GUERRA, L. G. WILSON, and G. B. NORTHAM (NASA, Langley Research Center, Hampton, VA) Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, Combustion Meeting, 23rd, Hampton, VA, Oct. 20-24, 1986, Paper. 15 p. refs

An atmospheric pressure tubular opposed jet burner technique was used to characterize certain diffusion-flame transitions and associated burning rates for N2-diluted mixtures of highly-reactive fuels. The paper presents: (1) details of the technique, with emphasis on features permitting the study of flames involving pyrophoric gases and particle-forming combustion reactions; (2) discoveries on the properties of these flames which correspond to physically and chemically distinct stages of silane and hydrogen combustion; and (3) unburnt gas velocity data obtained from flames based on SiH4-CH4-N2, SiH4-H2-N2, and H2-N2 fuel mixtures, and plotted as functions of combustible-fuel mole fraction and fuel/oxygen molar input flow ratios. In addition, these burning velocity results are analyzed and interpreted. K.K.

N87-15289# Science Applications, Inc., Chatsworth, Calif. Combustion Science and Advanced Technology Dept.
PRESSURE INTERACTIONS IN SUPERSONIC COMBUSTION Final Report, 1 Jun. 1984 - 28 Feb. 1986
R. B. EDELMAN and W. N. BRAGG 11 Jun. 1986 58 p
(Contract F49620-84-C-0064)
(AD-A172711; AFOSR-86-0876TR) Avail: NTIS HC A04/MF A01 CSCL 21B

A detailed assessment of supersonic combustion was carried out to identify specific research requirements in modeling turbulent reacting supersonic flows. The direct effects of pressure gradients and pressure fluctuations on turbulence were found to be potentially responsible for certain of the trends in turbulent transport and mixing rates that are observed in supersonic flows. An approach to the modeling of these phenomena is delineated. A modular model computer code for the analysis of sudden expansion (dump) combustors was prepared. This modular model is designed to be used parametrically in evaluating effects such as chemical kinetics limitation on flame stabilization and combustion efficiency in integral rocket ramjet and ducted rocket combustors. GRA

N87-15291# Technion - Israel Inst. of Tech., Haifa. Dept. of Aeronautical Engineering.
EFFECT OF COLD-WORKING BY HOLE EXPANSION ON FATIGUE LIFE OF 7075-T7351 AND 7475-T761 ALUMINUM LUGS WITH AND WITHOUT INITIAL FLAWS UNDER MANEUVER LOADING SPECTRUM
A. BUCH and A. BERKOVITS Jan. 1985 19 p
(TAE-561) Avail: NTIS HC A02/MF A01

The effect of cold working by hole expansion on fatigue life of aircraft lugs under maneuver and constant amplitude loading was investigated. Of the two nominal expansion levels used, 2 percent expansion resulted in greater life improvement than the larger expansion of 3.3 percent. The reason for this was the relatively small w/d ratio and lug head shape distortion caused by the larger expansion. The hole expansion had a more beneficial effect in the case of lugs with 1 mm deep initial flaws than lugs without flaws. Hole expansion considerably improved the damage tolerence of the lugs investigated. Author

N87-15306# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero-Propulsion Lab.
CARBON RESIDUE STUDIES WITH A MICRO CARBON RESIDUE TESTER Final Report, Nov. 1984 - Oct. 1985
WILHELM BOCHARTZ Jun. 1986 71 p
(AD-A171153; AFWAL-TR-85-2099) Avail: NTIS HC A04/MF A01 CSCL 11H

A test procedure for the coking propensity of gas turbine lubricants was developed using the Micro Carbon Residue

Tester-100 (MCRT-100). The MCRT-1009, a microprocessor controlled heating unit, was evaluated for its ability to determine carbon residue in weight percent of synthetic gas turbine lubricants under controlled static conditions (various time/temperature profiles and selected gas atmospheres). The purpose was to yield information on the amount of deposit remaining in glass vials after a measured volume of lubricant had been exposed to different degrading environments, varying the parameters of temperature, gas (air or nitrogen), and exposure time. During a test, several processes occur simultaneously. The major effect is volatilization of the lubricant. Substantial oxidation and thermal degradation of the lubricant also occurs, which forms residue in the glass vials. The degradation of the lubricant is not completely realistic because the evaporated oil is caught in the condensate trap of the MCRT-100, whereas condensate returns to the bulk oil in an engine and affects viscosity, acidity, and the degradation of the lubricant. GRA

N87-16078# Massachusetts Inst. of Tech., Cambridge. Technology Lab. for Advanced Composites.
DYNAMICS AND AEROELASTICITY OF COMPOSITE STRUCTURES Final Report, 1 May 1984 - 30 Jun. 1985
JOHN DUGUNDJI and GUN-SHING CHEN 1 Mar. 1986 30 p
(Contract AF-AFOSR-0142-84)
(AD-A172922; TELAC-85-25; AFOSR-86-0892TR) Avail: NTIS HC A03/MF A01 CSCL 01C

An analytical and experimental investigation was made of the aeroelastic flutter and divergence behavior of graphite/epoxy forward swept wings with rigid body pitch and plunge freedoms present. A complete, two-sided 30-degree forward swept wing aircraft model was constructed and mounted with low friction bearing in a low speed wind tunnel. Four different ply layup wings could be interchanged on the model. Wind tunnel tests on the free flying models revealed body freedom flutter, bending torsion flutter, and a support dynamic instability which could be eliminated by proper adjustment of the support stiffness. Good agreement with linear theory was found for the observed instabilities. GRA

N87-16093# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
FUELS COMBUSTION RESEARCH Final Report, 1 Mar. 1982 - 30 Sep. 1985
FREDERICK L. DRYER, IRVIN GLASSMAN, and FORMAN A. WILLIAMS 9 Dec. 1985 42 p
(Contract F49620-82-K-0011)
(AD-A172429; MAE-1731; AFOSR-86-0841TR) Avail: NTIS HC A03/MF A01 CSCL 21B

The qualitative mechanisms for the oxidation of benzene and alkylated benzenes corresponds well with flow reactor results. Major results have been obtained on how the aromatic sidechain reacts and specific fundamental reaction rate data have been obtained. A fundamental correlation with respect to fuel C-C bonds for the sooting tendency of fuels under premixed combustion conditions has been developed and the concept that fuel structure plays no direct role in determining the critical sooting equivalence ratio was put forth and substantiated by results on pure fuels and fuel mixtures. Fuel structure and pyrolysis mechanisms have been found to be the important controlling factors in sooting diffusion flames. From a knowledge of basic pyrolysis studies, it is now possible to predict a fuel's reveal no synergistic trends with diffusion flame sooting trends; however, these trends may be due to the structural aspects of these flames. Experimental and theoretical research efforts on high-energy-density slurry propellants are reported. Transient internal heat conduction and liquid surface regression of a rigid slurry droplet during liquid vaporization and combustion have been investigated using singular perturbation methods. Experimentally, a technique to produce isolated slurry fuel droplets of boron and JP-10 has been developed, and observations on the isolated droplet combustion characteristics of several commercially prepared boron/JP-10 slurries were made. GRA

N87-16094# Purdue Univ., West Lafayette, Ind. Thermal Sciences and Propulsion Center.
FUEL SPRAY IGNITION BY HOT SURFACES AND AIRCRAFT FIRE STABILIZATION Final Report, 15 Nov. 1981 - 31 Mar. 1986
J. G. SKIFSTAD, A. H. LEFEBVRE, and S. N. MURTHY 1 Jun. 1986 33 p
(Contract AF-AFOSR-0107-82)
(AD-A172827; LMS/AFOSR-COMB/83; AFOSR-86-0856TR)
Avail: NTIS HC A03/MF A01 CSCL 21B

In Task 1 an experimental study of the ignition of Jet-A fuel sprays by an isothermal hot surface was conducted in a vertical axisymmetric duct. In addition to measurements of the wall temperature necessary for ignition, local measurements of velocity, turbulence intensity, fuel concentration, and the fraction of fuel vaporized were measured in the boundary layer at surface temperatures just below that required for ignition. In Task 2 two combustion tunnel facilities were used to investigate the stabilization of aircraft fires. Results showed that the shape of a bluff-body flameholder affects its stability characteristics through its influence on the size and shape of the wake region. Another significant finding was that the flameholding properties of the single-vortex flow pattern are markedly superior to those of the double-vortex pattern. In Task 3 experimental studies were conducted on: (1) Entrainment of an external flow into a cavity, with a small opening or vent in a side wall, when there is a small flow through the cavity; and (2) Fluid dynamics and ignition and flame stability characteristics of a jet of gaseous fuel through a protrusion of different shapes and heights in the wall of a cavity with a small flow of air through the cavity. GRA

N87-16146# Battelle Columbus Labs., Ohio.
THERMAL BARRIER COATINGS FOR ENGINE APPLICATIONS
J. A. COLWELL Aug. 1986 25 p
(Contract DLA900-83-C-1744)
(AD-A172983; MCIC-86-C2) Avail: NTIS HC A02/MF A01 CSCL 11C

The benefits of using thermal barrier coatings for engine applications have been considered. It has been found by a number of investigators that engine efficiencies can be dramatically improved by the use of these coatings. Most of the work done in the past was centered around the use of plasma-sprayed zirconia as the basis of the coating system. Various bond coats, needed for adherence and corrosion resistance, and concentrations of oxide stabilizers have been investigated. It appears that an MCrAlY bond coat beneath a zirconia coating containing 6 to 8 percent yttria as stabilizer is the most promising candidate for heat engine service. Coating adherence during thermal cycling and corrosion resistance of both the coating system and the underlying alloy substrate are of prime importance. GRA

N87-16157# Oak Ridge National Lab., Tenn.
CERAMIC TECHNOLOGY FOR ADVANCED HEAT ENGINES PROJECT Semiannual Progress Report, Apr. - Sep. 1985
May 1986 243 p
(Contract DE-AC05-84OR-21400)
(DE86-014332; ORNL/TM-9947) Avail: NTIS HC A11/MF A01

An assessment of needs was completed, and a five-year project plan was developed with input from private industry. The objective is to develop the industrial technology base required for reliable ceramics for application in advanced automotive heat engines. Focus is on structural ceramics for advanced gas turbine and diesel engines, ceramic bearings and attachments, and ceramic coatings for thermal barrier and wear applications in these engines. The work described in this report is organized according to the following WBS project elements: management and coordination; materials and processing (monolithics, ceramic composites, thermal and wear coatings, joining); materials design methodology (contact interfaces, new concepts); data base and life prediction (time-dependent behavior, environmental effects, fracture mechanics, NDE development); and technology transfer. This report includes contributions from all currently active project participants. DOE

N87-16182# Joint Publications Research Service, Arlington, Va.
COMBINED USE OF HYDROGEN AS FUEL ATOMIZER AND ADDITIONAL FUEL IN GAS-TURBINE ENGINE
P. M. KANILO *In its* USSR Report: Engineering and Equipment p 2 24 Feb. 1986 Transl. into ENGLISH from Mashinovedeniye (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 113-115
Avail: NTIS HC A07/MF A01

Use of hydrogen in gas turbine engines as gaseous agent for effective pneumomechanical atomization of liquid hydrocarbon fuel is considered, with the extra fuel this hydrogen provides as additional payoff. Analysis based on combustion thermodynamics and hydrodynamics, evaluation of mass balance and fuel economy, indicates significant advantages of such combined use of hydrogen typically during startup and low gas run. Calculations and numerical data applicable to gas turbine engines on YaK-40 and YaK-42 airplanes indicate, moreover, that such a use of hydrogen not only improves the combustion processes by facilitating its completion but also improves the engine reliability and lowers the toxicity level of exhaust emissions. Author

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ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A87-19686
A TECHNIQUE FOR THE OBJECTIVE MEASUREMENT OF MRTD
GLENN M. CUTHBERTSON, LESLIE G. SHADRAKE, and NEIL J. SHORT (GEC Avionics, Ltd., Electro-Optical Systems Group, Basildon, England) IN: Infrared technology and applications; Proceedings of the Meeting, Cannes, France, November 26-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 179-192. refs

The minimum resolvable temperature difference of a thermal imager is generally accepted as being the performance parameter most closely related to the imager's performance in the field. It is, however, universally conceded that an objective test technique is urgently required to replace the current subjective method of measurement, thus removing the dependence of trained operators. Simplistically this can, at first sight, be easily achieved via the measurement of the system modulation transfer function, noise power spectrum and signal transfer function. However, the practice of measuring these system parameters is not so straight forward. This paper deals with a practical implementation of such an objective method of testing, based upon a method proposed by the Royal Aircraft Establishment. It deals with the mathematical subtleties of applying the required discrete Fourier transforms in software and of integrating waveforms to achieve acceptable signal to noise ratios. The paper also gives examples of the objective results achieved, and a comparison with the corresponding subjective results. Author

A87-19689
TRANSIENT THERMAL TECHNIQUE FOR INFRARED NON DESTRUCTIVE TESTING OF COMPOSITE MATERIALS
HERVE TRETOUT and JEAN-YVES MARIN (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) IN: Infrared technology and applications; Proceedings of the Meeting, Cannes, France, November 26-29, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 277-284. refs

A large investigation program is carried out in order to define the field of application of thermography to composite materials evaluation, to set up a method which can be industrialized, and to write down specifications for an industrial installation. Thermophysical properties of the materials, different heat sources, infrared detectors and image processing systems are investigated. Calibration of the apparatus is also considered. An original method using the combination of a line heater, a line scanner, and a real time digital signal processing and recording system is presented. Author

A87-19807
HOLOGRAPHIC INTERFEROMETRY OF ROTATING COMPONENTS DECORRELATION LIMITATIONS OF THE DOUBLE PULSED TECHNIQUE
PHILIP A. STOREY (Rolls-Royce, Ltd., Derby, England) IN: Optics in engineering measurement; Proceedings of the Meeting, Cannes, France, December 3-6, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 66-73.

A determination is made of those conditions at which rotation compensation is required during pulsed holographic study of rotating turbomachine component structures. Attention is given to the relationships defining the minimum achievable fringe spacing, optimum pulse separation, and reconstruction system f-number for the standard double-pulsed technique. The case of a turbofan rotor is treated. O.C.

A87-19810
AUTOMATIC FRINGE ANALYSIS IN DOUBLE EXPOSURE AND LIVE FRINGE HOLOGRAPHIC INTERFEROMETRY
D. W. ROBINSON and D. C. WILLIAMS (National Physical Laboratory, Teddington, England) IN: Optics in engineering measurement; Proceedings of the Meeting, Cannes, France, December 3-6, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 134-140. Research supported by the Ministry of Defense (Procurement Executive) and Rolls-Royce, Ltd. refs

In general the automatic analysis of double-exposure and live fringe holographic interferograms requires different and complementary approaches to the development of digital image processing software. In the former case, intensity pattern analysis must be performed, whereas in the latter, phase modulation techniques are applicable. Examples of both types of analysis will be presented, in the context of developing holographic measurement systems for use in the determination of surface deformation and strain fields in engineering components. Author

A87-20079#
ADVANCED PRESSURE MOLDING AND FIBER FORM MANUFACTURING TECHNOLOGY FOR COMPOSITE AIRCRAFT/AEROSPACE COMPONENTS
NEIL C. OLSEN and HENRY L. CHESS (XERKON Co., Minneapolis, MN) IN: Reinforced Plastics/Composites Institute, Annual Conference, 41st, Atlanta, GA, January 27-31, 1986, Preprint . Lancaster, PA, Technomic Publishing Co., 1986, 5 p.

A87-20080#
COMPOSITE PLY MANAGEMENT
ALLEN E. TRUDEAU and PETER C. CYR (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: Reinforced Plastics/Composites Institute, Annual Conference, 41st, Atlanta, GA, January 27-31, 1986, Preprint . Lancaster, PA, Technomic Publishing Co., 1986, 3 p.

Composite Ply Management is a technology in which composite components are evaluated for producibility during the design and manufacturing processes. Ply geometries are developed during the design phase taking into consideration cutting, kitting, lamination and material cost. These ply designs include a unique number for identifying the order of lay-up and to allow for material tracking from procurement to aircraft installation; designs are then interactively nested to minimize spillage and to ensure a repeatable data base. Automated cutting techniques are used to reduce cutting costs and guarantee consistency. The designs are then evaluated on the shop floor for producibility, during which instructional lay-up books are developed. Composite Ply Management has produced labor savings in excess of 40 percent and material savings of 50 percent. Author

A87-20087#
CONDUCTIVE BARRIER PRIMER FOR COMPOSITE AIRCRAFT PARTS
R. A. BRUNING and P. DONECKER (Fairchild Republic Co., Farmingdale, NY) IN: Reinforced Plastics/Composites Institute, Annual Conference, 41st, Atlanta, GA, January 27-31, 1986, Preprint . Lancaster, PA, Technomic Publishing Co., 1986, 3 p.

A coating system has been developed for composite laminates used in aircraft structures which, while furnishing protection against effects of weathering, chemical corrosion and flight-related deterioration, also satisfies the requirement for static charge-dissipating electrical conductivity and good surface filling. Exonomic advantages can be realized by means of this coating system in virtue of reductions in labor costs; weight savings are also obtained. O.C.

A87-20165
USE OF ULTRASONIC MODELS IN THE DESIGN AND VALIDATION OF NEW NDE TECHNIQUES
R. B. THOMPSON and T. A. GRAY (DOE, Ames Laboratory, IA) (Royal Society, Discussion on Novel Techniques of Non-Destructive Examination and Validation, London, England, July 9, 10, 1985) Royal Society (London), Philosophical Transactions, Series A (ISSN 0080-4614), vol. 320, no. 1554, Nov. 26, 1986, p. 329-340; Discussion, p. 340. refs

In implementing fracture-mechanics-based techniques for the design and life extension of structural components, it is necessary to establish the reliability with which various flaw sizes and types can be detected and characterized. Traditionally, this has been accomplished through extensive experimental demonstration programs. This paper discusses present efforts to use model predictions to reduce the required amount of experimentation, and hence the cost, of such programs. Formalisms whereby the extensive elastic-wave theoretical scattering effort of the last decade can be applied to practical problems are first reviewed. This is followed by several specific examples which have occurred in the nuclear and aerospace industries. Author

A87-20170
ON THE EFFICIENCY OF STIFFENED PANELS, WITH APPLICATION TO SHEAR WEB DESIGN
A. ROTHWELL (Delft, Technische Hogeschool, Netherlands) IN: Aspects of the analysis of plate structures: A volume in honour of W. H. Wittrick . Oxford and New York, Oxford University Press, 1985, p. 105-125. refs

The efficiency of a panel is a measure of its ability to carry some required loading for the least weight - or with the most economical use of the material of which it is made. Through the definition of efficiency, comparisons can be made between different forms of construction and different materials, and the significance of practical restrictions imposed by the designer can be assessed. Criteria for the design of stiffened panels, based on the concept of efficiency, are reviewed. The shear web is chosen as a suitable example, and various results are presented for conventional stiffened webs, truss webs, post-buckled designs, and webs of corrugated cross-section. Author

A87-20346
MONITORING THE STATE OF THE BLADES OF GAS TURBINE ENGINES BY THE ACOUSTIC EMISSION METHOD [KONTROL' SOSTOIANIIA LOPATOK GAZOTURBINNYKH DVIGATELEI METODOM AKUSTICHESKOI EMISSII]
M. D. BANOV, D. A. TROENKIN, A. I. URBAKH, and S. F. MINATSEVICH (Rizhskii Institut Inzhenerov Grazhdanskoi Aviatsii, Riga, Latvian SSR) Defektoskopiia (ISSN 0130-3082), no. 9, 1986, p. 58-63. In Russian.

Experiments are reported in which acoustic emission was used for monitoring the condition of the cooled blades of gas turbine engines. An analysis of the results obtained demonstrates that the acoustic emission method makes it possible to detect defects in the internal cavities of the blades at stresses that do not exceed the operating stresses. Acoustic emission data for ten blades are compared with the results of metallographic analysis. V.L.

A87-20377
SELECTING THE TYPE OF A HYDRODYNAMIC DAMPER FOR GAS-TURBINE ENGINE ROTOR SUPPORTS [VYBOR TIPA GIDRODINAMICHESKOGO DEMPFERA DLIA OPOR ROTOROV GTD]
A. I. BELOUSOV and D. K. NOVIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 7-11. In Russian. refs

A solution is presented for the problem of the forced vibrations of a symmetric rigid rotor using hydrodynamic dampers of various types (short, long, and slotted). Based on the solution, an algorithm is developed for selecting the appropriate damper type for a given rotor. The procedure for selecting an appropriate damper is demonstrated by an example. V.L.

A87-20385
THE EFFECT OF THE ROTATION FREQUENCY ON THE EFFICIENCY OF A CENTRIFUGAL SCREW PUMP UNDER STEADY AND UNSTEADY CONDITIONS [VLIIANIE CHASTOTY VRASHCHENIIA NA KPD SHNEKOTSENTROBEZHNOGO NASOSA USTANOVIVSHIKHSIA I NEUSTANOVIVSHIKHSIA REZHIMAKH]
V. V. CHERVAKOV, E. N. BELIAEV, N. S. ERSHOV, and B. V. OVSIANNIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 40-43. In Russian. refs

The relationship between the efficiency and the flow coefficient of centrifugal screw pumps under steady and unsteady operation is investigated as a function of the rotation frequency. The applicability limits of the existing formulas for calculating changes in pump efficiency with the rotation frequency are determined. Calculations for three pumps are compared with experimental results. V.L.

A87-20388
SPECTRAL COMPOSITION OF THE FORCES EXCITING VIBRATIONS IN TURBOMACHINES [O SPEKTRAL'NOM SOSTAVE SIL, VOZBUZHDAIUSHCHIKH VIBRATSII V TURBOMASHINAKH]
B. I. BOROVSKII, A. I. CHUCHEROV, and V. L. KHITRIK Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 49-51. In Russian. refs

The reduction of aerodynamic perturbation forces and of the resulting flow inhomogeneities provides a way to reduce vibrations in turbomachines. Here, the spectral composition of the forces responsible for vibration excitation, which are approximated by a periodic function, is determined in the context of a physical model of vibrations by representing the periodic function in the form of a Fourier series. Some particular cases are examined. V.L.

A87-20393
AN EXPERIMENTAL STUDY OF THE NEARLY ISOTHERMAL OPERATING CONDITIONS OF LOW-TEMPERATURE HEAT PIPES [EKSPERIMENTAL'NOE ISSLEDOVANIE REZHIMOV RABOTY NIZKOTEMPERATURNYKH TEPLOVYKH TRUB, BLIZKIKH K IZOTERMICHESKIM]
N. I. KLIUEV, V. V. KOSTENKO, A. L. LUKS, V. I. MIKHEEV, and V. IA. CHERNOBRIVETS Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 61, 62. In Russian.

The objective of the study is to investigate the possibility of using low-temperature acetone heat pipes for the thermostatic control of the electron equipment of aircraft operating in the temperature range 278-313 K. With reference to test results for cylindrical heat pipes made of ADZ1T1 aluminum alloy with a wall capillary structure with rectangular grooves, it is shown that low-temperature heat pipes can provide efficient thermostatic control at moderate thermal loads and temperatures. A method for testing heat pipes is also proposed which eliminates the effect of gravitational forces. V.L.

A87-20394
OPTIMIZATION OF A PROCESS FOR THE SURFACE HARDENING OF STRUCTURAL PARTS USING THE FATIGUE LIMIT CRITERION [OPTIMIZATSIIA TEKHNOLOGII POVERKHNOSTNOGO UPROCHNENIIA SILOVYKH DETALEI PO KRITERIIU PREDELA VYNOSLIVOSTI]
G. N. KRAVCHENKO and I. N. CHILIKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 63-65. In Russian. refs

Plastic surface treatments are commonly used for increasing the fatigue strength of aircraft structures. Here, an analytical-experimental method is proposed for selecting the principal parameters of shot blasting using a criterion based on the fatigue limit of the treated component. A block diagram of the procedure for determining the conditions of a shot blasting treatment is presented. The initial data for optimization include the mechanical characteristics of the part material, geometrical parameters of the part, the principal parameters characterizing the initial condition of the surface layer, characteristics of the shot blasting equipment, and some experimental data on the hardenability of the material. V.L.

A87-20403
EQUIVALENT LINE TRANSFORMATIONS DURING THE DESIGN OF ELECTRICAL NETWORKS USING THE MINIMUM-MASS CRITERION [EKVIVALENTNYE PREOBRAZOVANIIA LINII PRI PROEKTIROVANII ELEKTRICHESKIKH SETEI PO KRITERIIU MASSY]
O. P. SHCHEDKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 87-90. In Russian.

An analysis is made of two types of equivalent transformations of optimal radial branched (tree-like) networks, i.e., convolution and decomposition, which simplify the solution of optimization problems in the design of the electrical networks of aircraft. The optimization criterion used here is the minimum mass of the wiring. The analysis indicates that an optimum network can be replaced by equivalent radial lines. This conclusion is valid for both ac and dc networks when the minimal permissible voltages at the receivers are equal. V.L.

A87-20889#
EXPERIMENTAL INVESTIGATION ON ADVANCED COMPOSITE-STIFFENED STRUCTURES UNDER UNIAXIAL COMPRESSION AND BENDING
GIULIO ROMEO (Torino, Politecnico, Turin, Italy) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 283-292) AIAA Journal (ISSN 0001-1452), vol. 24, Nov. 1986, p. 1823-1830. Previously cited in issue 13, p. 1858, Accession no. A85-30259. refs

A87-20950
A HIGHER ORDER ELEMENT FOR STEPPED ROTATING BEAM VIBRATION
G. SUBRAMANIAN (Indian Institute of Technology, Madras, India) and T. S. BALASUBRAMANIAN (National Aeronautical Laboratory, Bangalore, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 110, Oct. 8, 1986, p. 167-171. refs

A higher order rotating element has been developed for helicopter rotor vibration studies which gives special attention to stepped rotating beam vibration through the consideration of: (1) deflection, (2) slope, (3) bending moment, and (4) shear force, as the degrees-of-freedom at each node. This ensures the proper matching of the compatible physical quantities between elements at the steps. The rotating element in this form is entirely novel. O.C.

A87-20952
A NEW PYRGEOMETER
J. S. FOOT (Royal Aircraft Establishment, Farnborough, England) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 3, Sept. 1986, p. 363-370. refs

Pyrgeometer measurements of the broadband infrared irradiance have hitherto been limited in accuracy because temperature gradients within the instrument produce spurious signals. A new pyrgeometer that has been demonstrated to possess greatly reduced sensitivity to temperature gradients is described. The instrument uses a thermopile evaporated onto a planar substrate with the hot and cold junctions having different adsorption properties. Both laboratory and aircraft flight tests are reported: comparison between the new instrument and an Eppley pyrgeometer is made. Features of the spectral selectivity of the instrument are also presented. Author

A87-20963#
CLOUD SIGNALS FROM LIDAR AND ROTATING BEAM CEILOMETER COMPARED WITH PILOT CEILING
W. L. EBERHARD (NOAA, Wave Propagation Laboratory, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 3, Sept. 1986, p. 499-512. refs

Cloud signals from a vertically pointing, range-corrected ruby lidar and a rotating beam ceilometer showed excellent agreement in the height at which peak signal occurred. However, pilot reports of ceiling were at significantly lower altitude when viewed at 3 deg below horizontal without the aid of approach lights. An analytical relationship is derived that connects pilot's optical depth with an idealized lidar's signal profile by applying reasonable approximations to the cloud structure. The view angle of the pilot, the lidar's pointing direction, and the vertical distribution of the obscuring particles control the relationship. This relationship is recommended as the foundation of a signal-processing algorithm for better ceiling measurements, particularly for low stratus. Author

A87-21020#
USE OF TRACERS FOR HYDRODYNAMIC VISUALIZATION AND MEASUREMENTS IN STEADY VORTEX FLOWS
M. GALLON (ONERA, Chatillon-sous-Bagneux, France) (National Association for Technical Research, International Symposium on Flow Visualization, 4th, Paris, France, Aug. 26-29, 1986) ONERA, TP, no. 1986-91, 1986, 7 p.
(ONERA, TP NO. 1986-91)

For many years, the hydrodynamic visualization laboratory has been known for analyzing vortex phenomena. The tracers used show the organized or unorganized structure of steady concentrated vortices forming above airfoils at an angle of attack and, in particular, the path of the axis of their cores, thus allowing position and velocity measurements to be obtained directly on the photographs or films made during the tests. These tracers also facilitate correct positioning of probes or measuring instruments, for instance a vortex meter, by giving information on the disturbances that can be caused by their presence in the center of the vortex core. Author

A87-21026#
A NUMERICAL STUDY OF THE PROPAGATION OF A DISTORTION IN AN AXIAL COMPRESSOR [ETUDE NUMERIQUE DE LA TRANSMISSION D'UNE DISTORSION DANS UN COMPRESSEUR AXIAL]
GERMAIN BILLET, PHILIPPE CHEVALIER, and PIERRE LAVAL (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Engine Response to Distorted Inflow Conditions, Munich, West Germany, Sept. 8, 9, 1986) ONERA, TP, no. 1986-107, 1986, 15 p. In French. DRET-supported research. refs
(ONERA, TP NO. 1986-107)

A finite difference model (LABICHE) employing purely unsteady fractional steps was applied to solve the Euler equations describing a flow with azimuthal turbulence moving through an axial compressor. The computations were performed by coupled integral equations for conservation of mass, energy and motion and retarded equations for the flux profile and the load loss. A final equation traced the radial evolution of the streamlines across blade rows. Comparisons between model predictions and experimental data demonstrated the model capabilities up to the point of strong boundary layer separation. M.S.K.

A87-21044#
MEASUREMENT OF DEFORMATIONS OF MODELS IN A WIND TUNNEL [MESURE DES DEFORMATIONS DES MAQUETTES EN SOUFFLERIE]
F. CHARPIN, C. ARMAND, and R. SELVAGGINI (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Static Aeroelasticity Effects on High-Performance Aircraft, Athens, Greece, Oct. 1, 2, 1986) ONERA, TP, no. 1986-126, 1986, 21 p. In French.
(ONERA, TP NO. 1986-126)

Techniques used at the ONERA Modane Center to monitor geometric variations in scale-models in wind tunnel trials are described. The methods include: photography of reflections from mirrors embedded in the model surface; laser-based torsiometry with polarized mirrors embedded in the model surface; predictions of the deformations using numerical codes for the model surface mechanical characteristics and the measured surface stresses; and, use of an optical detector to monitor the position of luminous fiber optic sources emitting from the model surfaces. The data enhance the confidence that the wind tunnel aerodynamic data will correspond with the in-flight performance of full scale flight surfaces. M.S.K.

A87-21062#
AIR INTAKE FLOW VISUALIZATION
M. PHILBERT, J. P. FALENI, and R. DERON (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-162, 1986, 7 p. refs
(ONERA, TP NO. 1986-162)

In order to visualize air flow separation phenomena in an aircraft air inlet model, an experiment based on the 'laser tomoscopy' method has been implemented in the large industrial wind-tunnel F1 at the Fauga-Mauzac ONERA center near Toulouse. This paper presents technical contents of the process as preliminary results obtained by this means. Author

A87-21092#
THERMAL SENSORS UTILIZING THIN LAYER TECHNOLOGY APPLIED TO THE ANALYSIS OF AERONAUTICAL THERMAL EXCHANGES [CAPTEURS THERMIQUES UTILISANT LA TECHNOLOGIE DES COUCHES MINCES APPLIQUEES A L'ANALYSE DES ECHANGES THERMIQUES EN AERONAUTIQUE]
J. C. GODEFROY, C. GAGEANT, and D. FRANCOIS (ONERA, Chatillon-sous-Bagneux, France) (Journees d'Etudes sur les Mesures de Temperature, Paris, France, Dec. 16, 17, 1986) ONERA, TP, no. 1986-193, 1986, 9 p. In French. refs
(ONERA, TP NO. 1986-193)

Thin film surface thermometers and thermal gradient fluxmeters developed by ONERA to monitor thermal exchanges in aircraft engines to predict the remaining service life of the components are described. The sensors, less than 80 microns thick, with flexible Kapton dielectric layers and metal substrates, are integrated into the shape of the surface being monitored. Features of Cu-n, Ni-, Au-, and Cr-based films, including mounting and circuitry methods that permit calibration and accurate signal analysis, are summarized. Results are discussed from sample applications of the devices on a symmetric NACA 65(1)-012 airfoil and on a turbine blade. M.S.K.

A87-21196
BUCKLING AND VIBRATION OF A ROTATING BEAM
A. NACHMAN (Hampton University, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 109, Sept. 22, 1986, p. 435-443. refs
(Contract DAAG29-85-G-0074)

The equations for the vibration of a rotating beam, such as a helicopter blade, are exhibited. The beam is elastic (in general nonlinearly so), the description is geometrically exact, the axis of rotation does not necessarily pass through the beam's clamped end (precession) and cross-sectional shearing is accounted for by using a director theory. Particular attention is paid to the impossibility of vibration (or buckling) confined to a plane making an angle beta to the axis of rotation unless beta = pi/2 (or pi/2 or 0) or rotatory inertia is neglected. For purposes of illustration the analysis is specialized to describe Euler-Bernoulli and Timoshenko beams. Author

A87-21271
CONCERNING INVISCID SOLUTIONS FOR LARGE-SCALE SEPARATED FLOWS
F. T. SMITH (University College, London, England) Journal of Engineering Mathematics (ISSN 0022-0833), vol. 20, no. 3, 1986, p. 271-292. refs

The large-scale separated eddies set up behind a bluff body at high Reynolds number are considered, for steady laminar planar flow. The main eddies are massive and are controlled predominantly by inviscid mechanics, with uniform vorticity inside. Analytical and computational solutions of the massive-eddy (vortex-sheet) problem are then described. A further possibility studied is that, even with lateral symmetry assumed, there may still be an extra degree of nonsymmetry or skewing with respect to the streamwise direction. Small-scale separations, where a Benjamin-Ono equation also possibly yielding nonsymmetric solutions can come into play, are discussed briefly. Author

A87-21520#
FUEL NOZZLE AIR FLOW MODELING
B. K. SULTANIAN and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 15 p. refs
(AIAA PAPER 86-1667)

The paper presents air flow modeling of four simulated fuel nozzles for which recent laser anemometer measurements have been made in the near-field region of the free flow regime. In each case, the flow field is characterized by two coaxial swirling annular jets with an enclosed centerbody. Numerical solutions of the elliptic transport equations of continuity, momentum, and the standard k-epsilon turbulence model, are carried out on a boundary-fitted, curvilinear orthogonal grid. Although there is scope for further improvements, detailed comparison of calculations with measurements for both the mean flow and turbulence field for all the nozzles indicates the viability of the present flow modeling for practical applications. Author

A87-21534#
UNSTEADY HEAT TRANSFER COEFFICIENT ESTIMATION FOR LONG DURATION
JAMES K. HODGE, ALICE J. CHEN, and JAMES R. HAYES (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 10 p. refs
(AIAA PAPER 86-1240)

Measurements of convective heat rate is difficult in ground and flight tests due to thermal and chemical mismatches between gages and surface materials. Coaxial gages can be matched with metallic surfaces, and are attractive if the data reduction problem can be solved. An estimation algorithm with a Kalman filter is extended for coaxial gages with surface and backface temperature measurements. The algorithm estimates parameters for changes in heat transfer coefficient due to pitch sweep and due to time variations. Heat capacity, conductivity, and effective gage thickness are estimated. Results from a hypersonic wind tunnel test for a blunt plate, which is not thermally matched, are compared with numerical solutions of the Navier-Stokes and boundary layer equations. Author

A87-22421#
VORTICAL PATTERNS IN THE WAKE OF AN OSCILLATING AIRFOIL
M. M. KOOCHESFAHANI (California Institute of Technology, Pasadena) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(Contract AF-AFOSR-84-0120)
(AIAA PAPER 87-0111)

The vortical flow patterns in the wake of a NACA 0012 airfoil pitching at small amplitudes are studied in a low speed water channel. It is shown that a great deal of control can be exercised on the structure of the wake by the control of the frequency, amplitude and also the shape of the oscillation waveform. An important observation in this study has been the existence of an axial flow along the cores of the wake vortices. Estimates of the magnitude of the axial flow suggest a linear dependence on the oscillation frequency and amplitude. Author

A87-22466*# Atmospheric Science Associates, Bedford, Mass.
THREE-DIMENSIONAL TRAJECTORY ANALYSES OF TWO DROP SIZING INSTRUMENTS - PMS OAP AND PMS FSSP
H. G. NORMENT (Atmospheric Science Associates, Bedford, MA), A. QUEALY (Sverdrup Technology, Inc., Middleburg Heights, OH), and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0180)

Flow-induced distortions of water drop fluxes and speeds as seen by the PMS optical array probe (OAP) and the PMS forward scattering spectrometer probe (FSSP) are estimated via three-dimensional flow and trajectory calculation methods. The sensitivities of the instruments to water drop diameter, angle of attack, and free stream air speed are determined. The instruments are first placed in isolation and then mounted under the wing of a Twin Otter airplane. For the wing-mounted OAP at 4-deg angle of attack, partial flow stagnation under the uptilted wing causes a significant decrease in both the flux and speed for small water drops. For the wing-mounted FSSP, sensitivity is found to both angle of attack and free stream air speed. K.K.

A87-22476#
EFFECTS OF A DOWNSTREAM DISTURBANCE ON THE STRUCTURE OF A TURBULENT PLANE MIXING LAYER
M. M. KOOCHESFAHANI and P. E. DIMOTAKIS (California Institute of Technology, Pasadena) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. Research supported by the California Institute of Technology. refs
(Contract AF-AFOSR-84-0120)
(AIAA PAPER 87-0197)

The responses of the mixing layer in the regions upstream and downstream of a two-dimensional disturbance are studied using flow visualization and laser Doppler velocimetry. The disturbance is generated by a two-dimensional pitching airfoil located downstream of the splitter plate trailing edge. It is observed that at low forcing frequencies the region upstream of the disturbance is unaffected and the shear layer growth rate downstream is increased; for high forcing frequencies the flow structure in the upstream region is modified and the growth rate in the downstream area is unchanged. It is proposed that a coupling mechanism may cause these changes in the shear layer. I.F.

A87-22509*# Scientific Research Associates, Inc., Glastonbury, Conn.
DUCT FLOWS WITH SWIRL
TOMMY M. TSAI and RALPH LEVY (Scientific Research Associates, Inc., Glastonbury, CT) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. refs
(Contract NAS3-24224)
(AIAA PAPER 87-0247)

The physics of the flow interaction between swirl and secondary flow was studied in duct bends relevant to the design of advanced aircraft nozzle systems. Both laminar and turbulent subsonic flows were investigated in generic duct bends for different amounts of swirl. The flow calculations are based on an economical three-dimensional spatial marching method employed in an existing computer code (PEPSIG). The computational method and code were extended to allow azimuthal periodicity and solutions in which the polar coordinate singularity occurs in the interior of the flow field. These extensions are needed to address swirling flow and twisted centerlines arising in out-of-plane bends. It was found that appropriate amounts of swirl can reduce total pressure loss relative to nonswirling cases. This conclusion was found to be insensitive to computational mesh. Author

A87-22563*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL FLOWFIELD VISUALIZATION OF A HIGH ALPHA WING AT MACH 1.62
JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0329)

Experimental oil-flow and tuft patterns and vapor-screen flow-visualization data were obtained on a cambered wing model at Mach 1.62 for an angle-of-attack range of 0 to 14 deg. These data were used as flow diagnostic tools along with surface-pressure and force data and full-potential theory calculations. A large separation bubble was found on the lower wing surface at low angle of attack. The high-angle-of-attack flowfield was characterized by a large attached-flow leading-edge expansion followed by a cross-flow shock. At 14 deg, the cross-flow shock apparently induced discrete regions of streamwise separated flow which were clearly indicated in the vapor-screen and oil-flow photographs. Author

A87-22565#
3-D LASER VELOCIMETER INVESTIGATIONS OF A GENERIC FIGHTER FLOWFIELD
C. J. NOVAK and C. R. HUIE (Lockheed-Georgia Co., Advanced Flight Sciences Dept., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. Research supported by the Lockheed-Georgia Independent Research and Development Program. refs
(AIAA PAPER 87-0331)

In this study, the flowfield about a wind-tunnel model of a generic fighter aircraft has been investigated using 3-D Laser Velocimetry techniques. The wind-tunnel model was designed and fabricated using computer aided lofting and machining processes. The three-dimensional flowfield about the wing and strake regions on the model were measured using a nonintrusive 3-D Laser Velocimeter leading to a full 3-D description of the velocity field for two angle of attack cases. The results from the two cases depict the marked differences that may exist in the leading-edge vortex flows. At 10 degrees angle of attack the leading-edge vortex is seen to be attached to the wing with elevated core-axial velocities at all chordwise locations surveyed. However, flowfield surveys acquired at 21 degrees angle of attack indicate vortex breakdown by the presence of reversed core axial velocities. The findings are further substantiated by surface flow visualizations. Insight is provided into the behavior of the vortex dominated flowfield and, additionally, the data base also provides quantitative velocity field and turbulence intensity data required for correlation and validation of advanced computational fluid dynamics methods. Author

A87-22599#
A MODEL FOR EFFECTS OF LARGE-SCALE MOTION ON COAXIAL JET DEVELOPMENT
J. C. BENNETT (Connecticut, University, Storrs), C. A. WAGNER, and D. C. BRONDUM (U.S. Navy, Naval Underwater Systems Center, New London, CT) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0380)

A model has been developed to account for the effects of large-scale structures on the development of coaxial jet flow. The model is based upon the extensive experimental data available and includes both momentum and mass transport. It is shown

that the large-scale influence represents a significant portion of both types of transport in the initial region of the coaxial jet. Terms associated with the large-scale flow are selected to match experimental data. Initial efforts to evaluate the model have begun using INS3D, an incompressible Navier-Stokes solver. Author

A87-22819* Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
APPLICATION OF MULTIPLE OBJECTIVE OPTIMIZATION TECHNIQUES TO FINITE ELEMENT MODEL TUNING
CHARLES R. DEVORE, AARON R. DEWISPELARE (USAF, Institute of Technology, Wright-Patterson AFB, OH), and HUGH C. BRIGGS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Computers and Structures (ISSN 0045-7949), vol. 24, no. 5, 1986, p. 683-689. refs

This report examines tuning a finite element model using vector optimization techniques. Structural models using finite element theory often need to be adjusted so they can accurately simulate the real structure. The goal is to tune the model such that it will reproduce data derived from structural tests. First, the performance indices are extremized using multiple objective optimization theory, producing a set of possible solutions. Next, the solutions are rank ordered according to a decision maker's preferences to select the best answer. The tuning process was applied to a T-38 horizontal stabilizer. Numerous weighted solutions contained a best static deformation model, a best frequency model and three intermediate combinations of these two models. This automated procedure proved to be a versatile method capable of producing solutions for many types of tuning problems. Author

A87-22821
OPTIMUM DESIGN OF BEAMS WITH DIFFERENT CROSS-SECTIONAL SHAPES
YUNLIANG DING and BJORN J. D. ESPING (Kungl. Tekniska Hogskolan, Stockholm, Sweden) Computers and Structures (ISSN 0045-7949), vol. 24, no. 5, 1986, p. 707-726. refs

The minimum weight design problem for frame structures subject to stress and displacement constraints is treated. The cross-sectional dimensions are used as design variables, and the hybrid approximation technique, in combination with the dual method from mathematical programming, is used. Seven different cross-sectional shapes are treated, and four examples are solved. Author

A87-22928#
THE ROLE OF FLOW VISUALIZATION IN THE STUDY OF HIGH-ANGLE-OF-ATTACK AERODYNAMICS
ROBERT C. NELSON (Notre Dame, University, IN) IN: Tactical missile aerodynamics . New York, American Institute of Aeronautics and Astronautics, 1986, p. 43-88. refs

The flow around a slender aerodynamic shape, such as guided missile, is characterized by large regions of flow separation at high angles of attack; these regions may contain highly organized vortical flow structures which may be symmetric or asymmetric, steady or unsteady, or even devoid of coherent vortex structure (in which case the wake is entirely turbulent). Attention is presently given to flow visualization experiments that illuminate these aerodynamic conditions, employing schlieren, vapor screen, surface flow visualization, smoke streakline, smoke boundary layer, flow mapping, and hydrodynamic methods. O.C.

A87-23070
VISUAL SYSTEMS - THE STATE OF THE ART
DAVID SHORROCK (Rediffusion Simulation, Inc., Arlington, TX) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 586-590.

State-of-the-art, computer-generated image simulator visual systems typically encompass a data base which generates the model of the operating environment, an image generator, and a display system suitable for the applications envisaged. Two basic approaches to such systems are discernible: those employing hybrid raster/calligraphy and those using raster/continuous tone. Attention is presently given to such capabilities and elements of visual displays as texture effects, transparencies, fade level-of-detail management, animation effects, and image generator functions for daylight and night/dusk conditions, as well as prospective developments in this field. O.C.

A87-23226*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DIRECT DRAG AND HOT-WIRE MEASUREMENTS ON THIN-ELEMENT RIBLET ARRAYS
S. P. WILKINSON and B. S. LAZOS (NASA, Langley Research Center, Hampton, VA) IUTAM, Symposium on Turbulence Management and Relaminarization, Bangalore, India, Jan. 19-23, 1987, Paper. 12 p. refs

An experimental study of stream wise, near-wall, thin-element riblet arrays under a turbulent boundary layer has been conducted in low-speed air. Hot-wire data show that a single, isolated thin-element riblet causes formation of counter-rotating vortex-pairs with a spanwise wavelength of 130 viscous lengths. Abrupt shifts in turbulence intensity magnitude and peak location are observed for streamwise riblet arrays as spanwise riblet spacing is varied. Direct drag measurements show net drag reduction (up to 8.5 percent) over a wide range of riblet spacings along with behavior at discrete non-dimensional spacings indicative of vortex activity. Overall, the data suggest that more than one drag reduction mechanism may be involved. Author

N87-15364# Mobile Satellite Corp., King of Prussia, Pa.
MOBILE AVIATION SERVICES IN THE 1545-1559/1646.5-1660.5 MHZ BAND
J. D. KIESLING *In* ESA Proceedings of an ESA Workshop on Land Mobile Services by Satellite p 13-15 Sep. 1986
Avail: NTIS HC A08/MF A01

Plans in the U.S. for a national mobile satellite service (MSS) including satellite services to aviation for air traffic control and airline operational control are outlined. The MSS provides affordable mobile services in nonurban areas where terrestrially based systems are uneconomic. The MSS system also is available on a priority basis for aviation services, specifically AMSS(R) services involving safety and regularity of flight and other aviation services. The U.S. plan is expected to change the U.S. Tables of Allocations and proposes to change the International Table of Allocations so that MSS facilities can and will provide AMSS(R) services on a priority basis. Such arrangements can be implemented worldwide by administrations and organizations having similar interests. ESA

N87-15371# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mathematical Support Div.
PRODAT SYSTEM ARCHITECTURE
E. KRISTIANSEN *In* ESA Proceedings of an ESA Workshop on Land Mobile Services by Satellite p 43-46 Sep. 1986
Avail: NTIS HC A08/MF A01

The PRODAT experimental satellite-based mobile communication system is presented. The goal of PRODAT is to provide low rate data communication between mobile terminals on land mobiles, small ships, and aircraft and fixed users connected to a ground station via terrestrial networks. Primary design objectives are that the mobile terminals must be compact, have low power consumption, and the mass production cost must be low. In particular, the antenna design must be such that the antennas are easily installed and do not cause unacceptable air drag. The PRODAT uses MARECS-B2, located in geostationary orbit over the Atlantic Ocean and operated by INMARSAT. ESA

N87-15380# Department of Trade and Industry, Stevenage (England). Radio Regulatory Div.
FREQUENCY SPECTRUM ALLOCATION FOR A POTENTIAL LAND MOBILE-SATELLITE SERVICE
D. P. WILLMETS *In* ESA Proceedings of an ESA Workshop on Land Mobile Services by Satellite p 93-94 Sep. 1986
Avail: NTIS HC A08/MF A01

Frequency spectrum allocation for a potential land mobile satellite service is discussed. There are no suitable primary or secondary allocations but the agenda for WARC(MOBILE)87 permits amendments to the International Table of Frequency Allocations. It is argued that it is necessary to identify the answers to key questions such as the likely demand, user needs, and spectrum requirements. Until the aeronautical mobile satellite (R) bands at 1.5/1.6 GHz are required, land mobile satellite systems could possibly operate. However, systems would not be able to operate in these bands (or any possible alternative frequency bands) with any security of tenure, unless changes are made to the International Table. ESA

N87-15381# Mobile Satellite Corp., King of Prussia, Pa.
THE UNITED STATES MOBILE SATELLITE SERVICE
J. D. KIESLING *In* ESA Proceedings of an ESA Workshop on Land Mobile Services by Satellite p 95-98 Sep. 1986
Avail: NTIS HC A08/MF A01

The proposed U.S. mobile satellite service provides services to America's nonurban land mass where terrestrial mobile systems find little application. Based on state of the art satellite technology, and use of omnidirectional, steered, and fixed antennas, a broad range of services at affordable prices will be available, including land mobile, service to intra coastal waterways, and aviation. ESA

N87-15397# Naval Ocean Systems Center, San Diego, Calif.
RADIATION RESISTANCE OF THIN ANTENNAS OF ARBITRARY ELEVATION AND CONFIGURATION OVER PERFECTLY CONDUCTING GROUND Interim Report, Dec. 1985 - Jun. 1986
R. A. PAPPERT Jun. 1986 66 p
(AD-A170945; NOSC/TR-1112) Avail: NTIS HC A04/MF A01 CSCL 09E

Dipole segmentation is used to estimate the radiation resistance of thin antennas of arbitrary elevation and configuration over a perfectly conducting ground plane. Sample results include half-wave linear antennas of varying inclination, half-wave spiral type antennas, and a TACAMO configuration. Utility of the method for estimating the radiation resistance of VLF/LF trailing-wire antennas from aircraft depends upon the extent to which the current distribution deviates from a sinusoid. That deviation is due in part to finite wire thickness as well as to the finite conductivity of both wire and ground. The influence of those effects requires further study. Author (GRA)

N87-15407# Lightning and Transients Research Inst., St. Paul, Minn.
AN EXPERIMENTAL AND THEORETICAL STUDY OF NUCLEAR-EMP (ELECTROMAGNETIC PULSE)-TYPE LIGHTNING SIMULATORS WITH COMBINED PEAKING CAPACITOR AND CROWBAR Final Report, Aug. 1984 - Mar. 1985
JOHN D. ROBB and RODNEY A. PERALA Mar. 1986 35 p
(Contract F33615-84-C-3405)
(AD-A172648; AFWAL-TR-86-3045) Avail: NTIS HC A03/MF A01 CSCL 20N

Experimental and theoretical studies have been carried out to determine the fesibility of combining nuclear electromagnetic-pulse-type lightning simulators which use peaking capacitors with crowbar switches to provide both a double exponential lightning test pulse with a long unipolar tail and a very fast risetime. The purpose of the simulator is to provide a relatively economical and simple lightning simulator for the indirect effects testing of full sized advanced composite aerospace vehicles. The theoretical analysis and experimental investigations have verified the validity of the concept of combining the peaking capacitor and the crowbar switch to obtain high-current waveforms which also have a high current rate of rise with economical components. GRA

N87-15466*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEW GENERATION METHODS FOR SPUR, HELICAL, AND SPIRAL-BEVEL GEARS
F. L. LITVIN (Illinois Univ., Chicago), W.-J. TSUNG, J. J. COY (Army Aviation Research and Technology Activity, Cleveland, Ohio), R. F. HANDSCHUH, and C.-B. P. TSAY (National Chiao Tung Univ., Hsinchu Taiwan) Nov. 1986 26 p Presented at the Rotary Wing Propulsion System Specialist Meeting, Williamsburg, Va., 12-14 Nov. 1986; sponsored by American Helicopter Society
(NASA-TM-88862; E-3216; NAS 1.15:88862;
USAAVSCOM-TR-86-C-27) Avail: NTIS HC A03/MF A01 CSCL 13I

New methods for generating spur, helical, and spiral-bevel gears are proposed. These methods provide the gears with conjugate gear tooth surfaces, localized bearing contact, and reduced sensitivity to gear misalignment. Computer programs have been developed for simulating gear meshing and bearing contact. Author

N87-16176 Department of the Air Force, Washington, D.C.
HEATER BLOCK ASSEMBLY FOR USE IN THERMAL OXIDATION TESTING OF JET FUEL Patent
ROBERT A. HARVEY, inventor (to Air Force) and ROBERT W. MORRIS, JR., inventor (to Air Force) 17 Jun. 1986 6 p Supersedes US-Patent-Appl-SN-651983
(AD-D012472; US-PATENT-4,595,824;
US-PATENT-APPL-SN-651983; US-PATENT-CLASS-219-302)
Avail: US Patent and Trademark Office CSCL 21D

This patent discloses a heater block assembly for a jet fuel test apparatus which has back and front plates with a test plate clamped inbetween. The test plate has a flat surface which faces the front plate, while the front plate has a raised ledge with a channel formed therein which faces the flat surface of the test plate. Inlet and outlet openings to opposite ends of the channel are formed through the front plate. When the back and front plates are clamped together with the test plate between, the flat surface of the test plate and the channel in the front plate together define a fuel sample flow passage. Thus, the fuel sample undergoing test is pumped through the inlet on the front plate into the flow passage where it flows along and in contact with the flat surface and out through the front plate. Electric heating rods in the back plate raise the temperature of the back plate and thereby the test plate and fuel sample, causing thermal decomposition deposits from the heated fuel to form on the flat surface of the test plate. GRA

N87-16181# Joint Publications Research Service, Arlington, Va.
TREATMENT OF TECHNICAL OBJECTS AS COMPLEX SYSTEMS
T. K. SIRAZETDINOV *In its* USSR Report: Engineering and Equipment p 1-2 24 Feb. 1986 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 3, Jul. Sep. 1984 p 70-74
Avail: NTIS HC A07/MF A01

Formalization and automation of new design in modern technology requires the system approach to an object. The simplest treatment of a technical object as a single entity is not adequate for new developments in aircraft technology, neither is the next step of treating it as one made of indivisible interacting components with more than one possible realization. The approach must be extrapolated to treating a technical object as a complex system. In this way, the history of design analysis and synthesis becomes analogous to a trajectory in the phase space up to any point representing the present status. Problems of optimal design can be formulated on this basis, considering a problem may be a multitarget one and that a global extremum may be sought as a solution implied to be unique. As problems become more multivariant or multicriterial, or both, for objects operating in more

than one mode, it becomes necessary to combine design and control of complex systems with appropriate simulation. The six basic methods of simulation for aircraft objects are: (1) as stochastic processes; (2) as sets or tubes defined mathematically by inequalities; (3) as sets of processes within the region of given motion describable by Liapunov functions; (4) with the mathematical apparatus of diffuse spaces; (5) with the aid of a characteristic function and mathematical logic calculus including predicates; and (6) by programming on a computer in the language best suited for a given algorithm of solution. Author

N87-16204# Army Test and Evaluation Command, Aberdeen Proving Ground, Md.
RADAR REFLECTIVITY Final Report
10 Jul. 1986 12 p Supersedes MTP-7-3-524
(AD-A173508; TOP-7-3-524; MTP-7-3-524) Avail: NTIS HC A02/MF A01 CSCL 17I

This TOP describes a method for measuring the radar reflectivity characteristics of aircraft. It uses a rotating platform and various radar systems to obtain calibrated radar Automatic Gain Control values for each degree of aspect angle for the aircraft. The purpose of this test is to provide comparable values of radar reflectivity for Army aircraft at various radar frequencies and parameter for fixed positions and aspect angles on the aircraft. Data collected on each specific aircraft can be used to evaluate radar reflectivity characteristics of aircraft skin material, paint, and structural changes such as flat versus curved surfaces. GRA

N87-16213# Pennsylvania Univ., Philadelphia. School of Electrical Engineering.
CONFORMAL MICROSTRIP SLOT ANTENNA AND ANTENNA ARRAY Interim Report, Mar. 1985 - Feb. 1986
MOSHE KISLIUK, BERNARD STEINBERG, and WILLIAM WHISTLER Sep. 1986 46 p
(Contract F19628-84-K-0021)
(AD-A174370; RADC-TR-86-0114) Avail: NTIS HC A03/MF A01 CSCL 09E

This study explores the wideband potential of a microstrip-fed slot radiator as an element of a planar or conformal antenna array. The microstrip slot is seen to have 40% input impedance bandwidth under 1.5 BSWR and a demonstrated 10% gain bandwidth to 3db. The report describes an analytic slot model and experimental tests. A conclusion of this report is that useful high efficiency radiators (greater than 80%) can be made by using the microstrip slot in N-element serial arrays. GRA

N87-16276# Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Md.
LASER SYSTEMS, AIRBORNE Final Report
11 Sep. 1986 41 p Supersedes MTP-6-E-166
(AD-A173775; TOP-6-3-166; MTP-6-E-166) Avail: NTIS HC A03/MF A01 CSCL 19E

This TOP describes tests for measuring and evaluating the capabilities of airborne laser systems in an airborne environment. It describes test procedures for testing range accuracy, target resolution, target illumination, communications systems, and substitute laser systems. GRA

N87-16362# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
ON THE BUCKLING OF SANDWICH BEAMS CONTAINING AN UNBONDED REGION M.S. Thesis
CARL J. FRUSHON May 1986 130 p Sponsored in part by NSF
(AD-A173603; AFIT/CI/NR-86-185T) Avail: NTIS HC A07/MF A01 CSCL 11F

This study involves a combined experimental and analytical analysis of the stability of a sandwich beam (overall length of 16.5 inches) with a partially unbonded faceplate. For simplicity, the beam considered was simply supported. Fully bonded beams as well as beams with unbonded lengths ranging from 0.5 to 5.0 inches were tested. Two failure regimes were observed. A distinct collapse load was evident in experiments with short unbond lengths (less than or = 2.0 inches). The loading histories of beams with longer unbond lengths (less than or = 3.0 inches) were found to be characterized by a limit load. In all cases, a transition form a symmetric to a nonsymmetric buckling shape occurred. The presence of the unbonded region was found to drastically reduce the load-carrying capacity of the sandwich structure. A power-law relationship was found between the unbond length and maximum load. The bonded sandwich beam was modeled as an assembly of three beams. This structure was assumed to be initially geometrically perfect. A solution was found numerically and began when the load within the unbonded faceplate was greater than the Euler buckling load for that section. Limit loads were predicted for all unbond lengths. The model was found to predict the failure load of a sandwich beam (unbond lengths less than or = 2.0 inches) to within 12.5%. GRA

N87-16364# General Dynamics Corp., Fort Worth, Tex.
ADVANCED DURABILITY ANALYSIS. VOLUME 3: FRACTOGRAPHIC TEST DATA Final Report, Oct. 1984 - Sep. 1985
D. E. GORDON, S. B. KIRSCHNER, L. E. BRUBAKER, K. KOEPSEL, and S. D. MANNING 1 Aug. 1986 245 p Prepared in cooperation with United Analysis Inc., Springfield, Va.
(Contract F33615-84-C-3208)
(AD-A173635; AFWAL-TR-86-3017-VOL-3) Avail: NTIS HC A11/MF A01 CSCL 20K

This report contains the test results and raw fractographic data for over 180 fatigue cracks. Natural fatigue cracks were acquired in fastener holes in 7475-T7351 aluminum. Three specimen fastener hole configurations were considered: (1) open hole, (2) bolt-in-hole(passive), and (3) bolt load transfer. Both straight-bore and countersunk fastener holes were considered. Strain survey results for a double-reversed dog-bone specimen(designed for 15% bolt load transfer) are presented. The fractographic data in this report can be used to quantify the initial fatigue quality or equivalent initial flaw size(EIFS) cumulative distribution for clearance-fit fastener holes. These data can be used to determine the initial flaw size for the durability and damage tolerance analyses of mechanically fastened joints. GRA

N87-16365# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
CORROSION AND LOAD TRANSFER EFFECTS ON FATIGUE OF MECHANICALLY FASTENED JOINTS
E. U. LEE 3 Feb. 1986 47 p
(AD-A173802; NADC-86026-60) Avail: NTIS HC A03/MF A01 CSCL 20K

To provide a technical basis for formulating a reliable service life prediction methodology of aircraft structures, it is essential to understand and quantify the load transfer effect on the fatigue behavior of mechanically fastened joints. The work presented in this report aims at characterizing the fatigue behavior of mechanically fastened joints and identifying the load transfer effect. With tests of low, medium, and high load transfer specimens of 7475-T7351 aluminum alloy, the fatigue crack initiation and growth, and the fracture behavior have been investigated, and the load transfer effect has been defined quantitatively. The results are compared to those of a zero load transfer specimen, reported previously. GRA

N87-16376# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
PRACTICAL APPLICATION OF FINITE ELEMENT ANALYSIS TO AIRCRAFT STRUCTURAL DESIGN
Loughton, England Aug. 1986 138 p Lectures held in Geilo, Norway, 11-12 Sep. 1986, in Lisbon, Portugal, 15-16 Sep. 1986, at McClellan AFB, Calif., 29-30 Sep. 1986, at Kelly AFB, Tex., 2-3 Oct. 1986, and at Wright-Patterson AFB, Ohio, 6-7 Oct. 1986
(AGARD-LS-147; ISBN-92-835-1536-6) Avail: NTIS HC A07/MF A01

This lecture introduces the main aspects of finite element analysis and modeling with emphasis placed on the solution of

practical design problems. An outline is given of the broad principles of the finite element method with some emphasis on the limitations of the technique. This is followed by an explanation of the modeling problems encountered in the analysis of real structures together with their resolution. The use of the finite element system is included.

N87-16380# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
THE USE OF THE FINITE ELEMENT METHOD
V. B. VENKAYYA *In* AGARD Practical Application of Finite Element Analysis to Aircraft Structural Design 39 p Aug. 1986
Avail: NTIS HC A07/MF A01

These lecture notes are primarily intended to provide a quick overview of the solid mechanics problem for engineers using a general purpose finite element system in the solution of aerospace structures problems. It gives a brief outline of the solid mechanics problem and some the available options for its solution. The finite element method is explained in more detail with particular emphasis on the use of membrane element in aerospace structural analysis. Author

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GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A87-22634#
USE, NON-USE, AND ABUSE OF WEATHER RADAR
EDWIN KESSLER (Oklahoma, University, Norman) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. refs
(AIAA PAPER 87-0441)

Radar systems for aviation weather forecasting are examined. The locations and capabilities of the national radar network are described. The advantages of airborne radars for storm avoidance during flight are discussed. Consideration is given to the functions and effective implementation of new radars with Doppler (Nexrad), which provide three-dimensional measurements of wind phenomena. I.F.

A87-22636#
FORECASTING AND CLASSIFYING DRY MICROBURST ACTIVITY IN THE DENVER AREA SUBJECTIVELY AND OBJECTIVELY
FERNANDO CARACENA (NOAA, Environmental Research Laboratory, Boulder, CO) and JOHN A. FLUECK (Cooperative Institute for Research in Environmental Sciences; NOAA, Environmental Research Laboratory, Boulder, CO) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0443)

Evidence is presented that microburst activity is predictable in the dry type of environment that commonly recurs near such western cities as Denver, CO. Both subjective and objective forecast schemes are described which are either driven by local sounding data or augmented by other regional soundings. On the basis of 1200 GMT sounding data, objective microburst forecasts are produced for the ensuing convective cycle which are verified by the observed daily microburst activity from the JAWS project. The objective schemes are driven by predictive linear models that use sounding-derived parameters as predictors and generate predictands that are some measure of microburst activity. Using the square root of the microburst count as one measure of this activity, such a scheme is able to account for about 30 percent of its variability. Using a three-level prediction scheme which is driven by three predictive linear functions, it is possible to classify microburst activity into three categories: none, few (1-4), and many (more than 4). The correct probabilities of detection are: none (70 percent), few (32 percent), and many (82 percent) for the single sounding scheme, and none (65 percent), few (55 percent), and many (82 percent) for the regional sounding scheme. Author

A87-22690#
IMPROVING AIRCRAFT ICING FORECASTS
JOHN W. HINKELMAN, JR. (PROFS Environmental Research Laboratories, Boulder, CO) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 4 p.
(AIAA PAPER 87-0532)

The paper describes a program for developing the capability to detect, monitor, and forecast aircraft icing conditions through the use of research, aircraft, and new remote sensing technology. The program objective is the timely, accurate delineation of actual and expected icing areas by location, altitude, duration, and potential severity. Author

A87-22753#
NOWCASTING LOW-ALTITUDE WIND SHEAR WITH A DOPPLER RADAR
MICHAEL D. EILTS (NOAA, National Severe Storms Laboratory, Norman, OK) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p. refs
(Contract DOT-FA01-80-Y-10524)
(AIAA PAPER 87-0642)

Using Doppler radar data collected on a number of moderate thundershowers in Oklahoma in June, 1986, a study examining precursors to microbursts was completed. A relationship was found between the radial convergence in the layer 1 to 5 km AGL and the impeding radial divergent outflow near the surface. It appears that convergence aloft associated with a descending reflectivity core may be a reliable precursor to microbursts. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A87-20379
SYNTHESIS OF PIECEWISE CONSTANT CONTROL WITH MEMORY FOR CONTINUOUS STOCHASTIC SYSTEMS [SINTEZ KUSOCHNO-POSTOIANNOGO UPRAVLENIIA S PAMIAT'IU DLIA NEPRERYVNYKH STOKHASTICHESKIKH SISTEM]
A. G. DEGTIAREV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1986, p. 14-18. In Russian.

The problem of the synthesis of piecewise constant control with memory is examined with particular reference to controlled systems (e.g., aircraft) whose parameters change with time. A closed system of continuously discrete equations is obtained for determining the characteristics of controlled motions and controller coefficients. As an example, a numerical solution is presented for the problem of the synthesis of piecewise constant control for the angular plane motion of a rigid aircraft with a fixed axis. V.L.

A87-20418
PROGRAM COMPONENTS OF SYNTHESIZING VISUALIZATION SYSTEMS [PROGRAMMNYE KOMPONENTY SINTEZIRUIUSHCIKH SISTEM VIZUALIZATSII]
A. V. GUSEV, S. L. IVASHIN, A. V. IOFFE, and E. A. TALNYKIN Avtometriia (ISSN 0320-7102), July-Aug. 1986, p. 14-17. In Russian. refs

Attention is given to the organization and composition of the software for the synthesizing visualization systems developed at the Automatic Control and Electrometry Institute of the Soviet

Academy of Sciences. In particular, such systems can be used for the purpose of flight simulation. B.J.

A87-21270* Old Dominion Univ., Norfolk, Va.
A COMBINED INTEGRATING- AND DIFFERENTIATING-MATRIX FORMULATION FOR BOUNDARY-VALUE PROBLEMS ON RECTANGULAR DOMAINS
W. D. LAKIN (Old Dominion University, Norfolk, VA) Journal of Engineering Mathematics (ISSN 0022-0833), vol. 20, no. 3, 1986, p. 203-215. Previously announced in STAR as N86-23350. refs
(Contract NAS1-17070; NAS1-18107)

Integrating and differentiating matrices allow the numerical integration and differential of functions whose values are known at points of a discrete grid. Previous derivations of these matrices were restricted to one dimensional grids or to rectangular grids with uniform spacing in at least one direction. Integrating and differentiating matrices were developed for grids with nonuniform spacing in both directions. The use of these matrices as operators to reformulate boundary value problems on rectangular domains as matrix problems for a finite dimensional solution vector is considered. The method requires nonuniform grids which include near boundary points. An eigenvalue problem for the transverse vibrations of a simply supported rectangular plate is solved to illustrate the method. Author

A87-22442#
THE FINITE CONTOUR METHOD
GAURAV RAJEN AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p. refs
(AIAA PAPER 87-0148)

The problem of transient heat conduction in a plate is solved using a discretization of the temperature field in the plate in terms of a finite number of isothermal contours. The method derived gives reasonable results for as few as three contours, and requires very little storage space and cpu time. A circular plate, an elliptic plate, and a Joukowski airfoil are considered as test problems. Author

A87-22528#
A ZONAL GRID GENERATION METHOD FOR COMPLEX CONFIGURATIONS
E. ATTA, L. BIRCKELBAW, and K. HALL (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0276)

An efficient grid generation scheme has been developed for realistic aircraft configurations. The scheme is based on a zonal approach that simplifies the grid generation process and permits greater flexibility in modeling three-dimensional geometries. In the present scheme, the computational space around a multicomponent aircraft configuration is divided into a number of non-overlapped blocks whose boundaries define the configuration surfaces and the limits of the computational space. H-type grids are generated independently in each region using a hybrid two-dimensional elliptic/algebraic grid generation algorithm. The block grids are then smoothly patched together along common surfaces to ensure proper transition from one block to another. Examples of the generated grids for fighter aircraft demonstrate the effectiveness of the zonal grid generation scheme in modeling complex configurations. Author

A87-23071
AN APPLICATION IN SIMPLICITY - THE BUILDING BLOCK TECHNIQUE OF TERRAIN DATA BASE GENERATION
ROBERTO ABASCAL, JR. and ROGER A. ALM (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 591-595. refs

A helicopter flight simulator requires a visual terrain data base of the highest quality in order to achieve acceptable results during nap-of-the-earth flight simulations. This data base's capabilities are constrained by physical memory storage, computer image generator capabilities, and the manpower required to compile a data base of the requisite complexity.Attention is presently given to a 'building block' method of visual terrain data base generation which addresses all of these constraints; the method is a modular software technique which generates a terrain data base on the basis of 'pieces' of generically modeled terrain. O.C.

A87-23072
AVIONICS SYSTEMS WITHIN A TRAINING ENVIRONMENT - HARDWARE VERSUS SOFTWARE MODELS
CHARLES W. GIBKE (LTV Aerospace and Defense Co., Dallas, TX) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 596-602.

Real-time training of modern air crews presents unique challenges to simulator designers in their decisions to utilize actual aircraft hardware in training systems. The advantages and disadvantages of using software models as replacements for avionics are discussed in this paper. References to the Navy's A-7E Weapon Systems Trainer (WST) will be used to demonstrate the pros and cons of implementing software models of modern avionics and weapons systems. The simulator, USN device 2F111, designed and built by LTV Aerospace and Defense, has been in operation for over ten years and incorporates both software models and avionics hardware for multipurpose pilot training. Examples will include the air data computer, navigation and weapons delivery computer, inertial measurement system, and electronic countermeasures system. Comparison will be made between various design parameters such as hardware/softwave development time, system performance, ease of modification, schedule impact, and cost. Author

A87-23073
SIMULATION EMULATION FOR PART-TASK SOFTWARE DEVELOPMENT
JOSEPH W. WARREN (General Dynamics Corp., Flight Simulation Laboratory, Fort Worth, TX) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 608-613.

An account is given of the development and operation of a part-task emulation which performs initial software checkout functions for a real time cockpit display system simulation. Specific emulation tasks are defined after simulation components have undergone prioritization. The emulation task for multifunction displays is rendered simpler by the use of subroutines generated for the Control Display Unit. Attention is presently given to the control software, switch panels, control display units, multifunction displays, airframe simulation, and debugging facilities encompassed by the system. O.C.

A87-23075
INTERFACING SYMBOLIC PROCESSES TO A FLIGHT SIMULATOR
M. M. BROADWELL and D. M. SMITH (Lockheed-Georgia Co., Marietta) IN: 1986 Summer Computer Simulation Conference, Reno, NV, July 28-30, 1986, Proceedings . San Diego, CA, Society for Computer Simulation, 1986, p. 751-755.

U.S. military contractors' requirements have recently prompted the development of systems that integrate conventional real time simulators with special purpose processors employed in AI applications. Attention is presently given to one such system that was developed in order to demonstrate the feasibility of performing real time expert system functions in conjunction with flight simulator operation; the system encompasses a VAX 11/780 computer, which drives a full six-degrees-of-freedom simulator that is linked by Ethernet to three LISP machines. The LISP machines are the bases of expert systems that perform situation assessment, tactics, route planning and intelligent implementation of this system are discussed. O.C.

N87-16553*# Grumman Aerospace Corp., Bethpage, N.Y.
DYCAST: A FINITE ELEMENT PROGRAM FOR THE CRASH ANALYSIS OF STRUCTURES Final Report
A. B. PIFKO, R. WINTER, and P. OGILVIE Washington NASA Jan. 1987 344 p
(Contract NAS1-13148)
(NASA-CR-4040; NAS 1.26:4040) Avail: NTIS HC A15/MF A01 CSCL 12A

DYCAST is a nonlinear structural dynamic finite element computer code developed for crash simulation. The element library contains stringers, beams, membrane skin triangles, plate bending triangles and spring elements. Changing stiffnesses in the structure are accounted for by plasticity and very large deflections. Material nonlinearities are accommodated by one of three options: elastic-perfectly plastic, elastic-linear hardening plastic, or elastic-nonlinear hardening plastic of the Ramberg-Osgood type. Geometric nonlinearities are handled in an updated Lagrangian formulation by reforming the structure into its deformed shape after small time increments while accumulating deformations, strains, and forces. The nonlinearities due to combined loadings are maintained, and stiffness variation due to structural failures are computed. Numerical time integrators available are fixed-step central difference, modified Adams, Newmark-beta, and Wilson-theta. The last three have a variable time step capability, which is controlled internally by a solution convergence error measure. Other features include: multiple time-load history tables to subject the structure to time dependent loading; gravity loading; initial pitch, roll, yaw, and translation of the structural model with respect to the global system; a bandwidth optimizer as a pre-processor; and deformed plots and graphics as post-processors. Author

N87-16557# Mississippi State Univ., Mississippi State. Dept. of Aerophysics and Aerospace Engineering.
GENERATION OF SURFACE GRIDS THROUGH ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS FOR AIRCRAFT AND MISSILE CONFIGURATIONS Interim Report, Apr. 1985 - Mar. 1986
Z. U. WARSI 9 May 1986 20 p
(Contract AF-AFOSR-0143-85)
(AD-A172867; AASE-86-293; AFOSR-86-1068TR) Avail: NTIS HC A02/MF A01 CSCL 12A

This report is devoted to a computational method of mesh generation in arbitrary surfaces by utilizing a set of elliptic partial differential equations. These equations depend explicitly on the mean curvature and the unit normal vector of the surface in which the coordinates are to be generated. To determine the mean curvature for a given surface in global coordinates, first a piecewise least squares method is used to fit a surface through the given data points. Next, mesh generation results for various geometrically complicated shapes have been obtained to demonstrate the versatility of the proposed equations. An example of a monoclinic coordinate system with contraction in the coordinate leaving the surface has also been presented. GRA

N87-16559*# Research Triangle Inst., Research Triangle Park, N.C. Center for Digital Systems Research.
EVALUATION OF RELIABILITY MODELING TOOLS FOR ADVANCED FAULT TOLERANT SYSTEMS Final Report
ROBERT BAKER and CHARLOTTE SCHEPER Oct. 1986 159 p
(Contract NAS1-16489)
(NASA-CR-178067; NAS 1.26:178067) Avail: NTIS HC A08/MF A01 CSCL 14D

The Computer Aided Reliability Estimation (CARE III) and Automated Reliability Interactice Estimation System (ARIES 82) reliability tools for application to advanced fault tolerance aerospace systems were evaluated. To determine reliability modeling requirements, the evaluation focused on the Draper Laboratories' Advanced Information Processing System (AIPS) architecture as an example architecture for fault tolerance aerospace systems. Advantages and limitations were identified for each reliability evaluation tool. The CARE III program was designed primarily for analyzing ultrareliable flight control systems. The ARIES 82 program's primary use was to support university research and teaching. Both CARE III and ARIES 82 were not suited for determining the reliability of complex nodal networks of the type used to interconnect processing sites in the AIPS architecture. It was concluded that ARIES was not suitable for modeling advanced fault tolerant systems. It was further concluded that subject to some limitations (the difficulty in modeling systems with unpowered spare modules, systems where equipment maintenance must be considered, systems where failure depends on the sequence in which faults occurred, and systems where multiple faults greater than a double near coincident faults must be considered), CARE III is best suited for evaluating the reliability of advanced tolerant systems for air transport. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A87-21195* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HELICOPTER IMPULSIVE NOISE - THEORETICAL AND EXPERIMENTAL STATUS
F. H. SCHMITZ and Y. H. YU (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 109, Sept. 22, 1986, p. 361-422. Previously announced in STAR as N84-19050. refs

The theoretical and experimental status of helicopter impulsive noise is reviewed. The two major source mechanisms of helicopter impulsive noise are addressed: high-speed impulsive noise and blade-vortex interaction impulsive noise. A thorough physical explanation of both generating mechanism is presented together with model and full-scale measurements of the phenomena. Current theoretical prediction methods are compared with experimental findings of isolated rotor tests. The noise generating mechanism of high speed impulsive noise are fairly well understood - theory and experiment compare nicely over Mach number ranges typical of today's helicopters. For the case of blade-vortex interaction noise, understanding of noise generating mechanisms and theoretical comparison with experiment are less satisfactory. Several methods for improving theory-experiment are suggested. Author

A87-22359#
HIGH SPEED FLIGHT EFFECTS ON NOISE PROPAGATION
R. H. BURRIN, K. K. AHUJA, and M. SALIKUDDIN (Lockheed-Georgia Co., Marietta) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 22 p. refs
(Contract F33615-85-C-3201)
(AIAA PAPER 87-0013)

An experimental study to investigate the effects of source motion on sound propagation at high Mach numbers was devised to determine, in particular, if the large amplifications in the forward arc to high speeds, predicted by the 'convective amplification' factors normally used for low speeds, are realistic. An acoustic point source and a microphone, both immersed in flows up to a Mach number of 0.8, were used to obtain the convective amplification factors for comparison with predictions. The results confirmed the existence of high levels of noise propagating ahead of an aircraft flying at high speed. The commonly adopted prediction formula, namely (1 - M sub 0 cos theta sub E) exp -4, was categorically confirmed by the data for frequencies up to 5 kHz and Mach numbers of 0.2 to 0.8. At higher frequencies, the predictions are followed up to emission angles of 120 deg, but then deviate downward towards the direction of flight. I.S.

A87-22512*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A PREDICTION OF HELICOPTER ROTOR DISCRETE FREQUENCY NOISE FOR THREE SCALE MODELS USING A NEW ACOUSTICS PROGRAM
KENNETH S. BRENTNER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0252)

A new computer program which uses Farassat's most advanced subsonic time domain formulation has been written to predict helicopter rotor discrete frequency noise. A brief description of the program, WOPWOP, is followed by a comparison of predicted and experimentally measured acoustic pressure and spectra for a 1/4 scale UH-1 model rotor blade and a 1/7 scale OLS (AH-1G) model rotor blade. The C81 computer program was used to predict the spanwise loading on the rotor for aerodynamic input into the acoustic prediction. Comparisons are made for different flight conditions and microphone locations with good results. In general the acoustic pressure is underpredicted. The acoustic predictions for a tapered rotor blade and predictions for microphones well below the tip path plane show less underprediction. Finally, in-plane motion of the rotor blade is shown to significantly affect the peak-to-peak amplitude of the acoustic pressure for high advancing tip Mach numbers. Author

A87-22513#
A COMPUTATIONAL AND EXPERIMENTAL STUDY OF HIGH-SPEED IMPULSIVE NOISE FROM A ROTATING CYLINDER
T. W. PURCELL (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0253)

This work presents an alternative to current integral approaches that do not accurately predict noise from a delocalized rotor. The two-dimensional model of this study is essentially an airfoil shape mounted on the side of cylinder which spins at transonic speeds between two end-walls. A finite-difference conservative formulation of the two-dimensional, transonic full-potential equations solves the flow field away from the body directly and hence predicts the beginning of delocalization and the associated wave propagation. The potential method has an inherent stability limit at a free-stream velocity of Mach 1.4 and shows a troubling sensitivity to the choice of outer boundary conditions. Methods for correctly handling these two problems are shown. A two-dimensional experiment that simulates the conditions assumed by the computer code is described. The computer prediction of the flow expected in the experiment is presented as are some limited experimental results. Results taken from a three-dimensional hovering rotor code show how the current two-dimensional results correlate to those from an actual rotor. Results for low-aspect-ratio rotors show a higher delocalization Mach number for decreasing aspect ratio and a greater dependence on thickness. Author

A87-22687#
COMPARISONS OF PREDICTED PROPELLER NOISE WITH WINDTUNNEL AND FLYOVER DATA
D. S. WEIR (PRC Kentron, Inc., Hampton, VA) and J. O. POWERS (FAA, Washington, DC) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(AIAA PAPER 87-0527)

The estimation of the farfield noise from propeller-driven aircraft is a complex problem. Certification standards require techniques for the adjustment of noise levels to reference conditions. A capability for predicting noise levels and a procedure for adjusting noise levels is presented. The NASA Aircraft Noise Prediction Program (ANOPP) is used to predict the propeller noise for a Piper Lance aircraft for comparison with FAA windtunnel and flyover data. Analytical and empirical scaling laws are presented for noise level adjustment. The comparison of ANOPP predictions with data demonstrates the capability of ANOPP to predict propeller noise for a variety of flight conditions. It produces parametric scaling laws for the adjustment of measured data to reference conditions. Author

A87-22688*# Southwest Research Inst., San Antonio, Tex.
TEST PROCEDURES FOR DETECTION OF IN-FLIGHT PROPELLER-INDUCED STRUCTURE-BORNE NOISE
J. F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(Contract NAS1-17921)
(AIAA PAPER 87-0528)

A potentially important source of structure-borne interior noise transmission in advanced turboprop aircraft is the impingement of the propeller wake/vortex on downstream aerodynamic surfaces. It can only be safely assumed that this potential source of interior noise may well hold up achievable interior noise levels unless noise control measures are conscientiously incorporated into the aircraft design. Through the use of a laboratory based test apparatus, techniques were developed to estimate the level of in-flight structure-borne noise transmission from combined frequency response function ground testing and in-flight structural response measurements. All phases of the test procedure were simulated in the laboratory and the expected level of accuracy of the procedure is addressed. Author

N87-16587*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTUREBORNE NOISE CONTROL IN ADVANCED TURBOPROP AIRCRAFT
IRVIN J. LOEFFLER Jan. 1987 24 p Presented at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA
(NASA-TM-88947; E-3362; NAS 1.15:88947; AIAA-87-0530)
Avail: NTIS HC A02/MF A01 CSCL 20A

Structureborne noise is discussed as a contributor to propeller aircraft interior noise levels that are nonresponsive to the application of a generous amount of cabin sidewall acoustic treatment. High structureborne noise levels may jeopardize passenger acceptance of the fuel-efficient high-speed propeller transport aircraft designed for cruise at Mach 0.65 to 0.85. These single-rotation tractor and counter-rotation tractor and pusher propulsion systems will consume 15 to 30 percent less fuel than advanced turbofan systems. Structureborne noise detection methodologies and the importance of development of a structureborne noise sensor are discussed. A structureborne noise generation mechanism is described in which the periodic components or propeller swirl produce periodic torques and forces on downstream wings and airfoils that are propagated to the cabin interior as noise. Three concepts for controlling structureborne noise are presented: (1) a stator row swirl remover, (2) selection of a proper combination of blade numbers in the rotor/stator system of a single-rotation propeller, and the rotor/rotor system of a counter-rotation propeller, and (3) a tuned mechanical absorber. Author

N87-16588*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASURED NOISE OF A SCALE MODEL HIGH SPEED PROPELLER AT SIMULATED TAKEOFF/APPROACH CONDITIONS
RICHARD P. WOODWARD Jan. 1987 29 p Presented at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA
(NASA-TM-88920; E-3352; NAS 1.15:88920; AIAA-87-0526)
Avail: NTIS HC A03/MF A01 CSCL 20A

A model high-speed advanced propeller, SR-7A, was tested in the NASA Lewis 9x15 foot anechoic wind tunnel at simulated takeoff/approach conditions of 0.2 Mach number. These tests were in support of the full-scale Propfan Text Assessment (PTA) flight program. Acoustic measurements were taken with fixed microphone arrays and with an axially translating microphone probe. Limited aerodynamic measurements were also taken to establish the propeller operating conditions. Tests were conducted with the

propeller alone and with three down-stream wing configurations. The propeller was run over a range of blade setting angles from 32.0 deg. to 43.6 deg., tip speeds from 183 to 290 m/sec (600 to 950 ft/sec), and angles of attack from -10 deg. to +15 deg. The propeller alone BPF tone noise was found to increase 10 dB in the flyover plane at 15 deg. propeller axis angle of attack. The installation of the straight wing at minimum spacing of 0.54 wing chord increased the tone noise 5 dB under the wing of 10 deg. propeller axis angle of attack, while a similarly spaced inboard upswept wing only increased the tone noise 2 dB. Author

N87-16590# Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.
NOISE LEVELS FROM URBAN HELICOPTER OPERATIONS, NEW ORLEANS, LOUISIANA
STEVEN R. ALBERSHEIM Jun. 1986 40 p
(AD-A174129; FAA-EE-86-04) Avail: NTIS HC A03/MF A01
CSCL 20A

The FAA conducted a noise monitoring program of helicopter operations at the Lakefront Airport in New Orleans, Louisiana. The purpose was to obtain noise measurements from helicopter operations in an urban environment. During this monitoring program the FAA concentrated solely on helicopter approaches to Lakefront Airport. The noise data was collected and classified as survey type data, since the monitoring program's measurements data obtained were from target of opportunity as opposed to a controlled test when the helicopter follow predefined flight path profiles. During the test period, ten different helicopter models were observed. Because of the high frequency of operations an opportunity was provided to determine the consistency between ALM values for the same helicopter model for different events. Since some of the monitoring sites were located in a residential community, an opportunity was provided to gather information on noise levels associated with a high frequency of helicopter operations. GRA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

A87-23262#
THE ORGANIZATION OF FLIGHT TESTING IN AN UNIVERSITY ENVIRONMENT
SHAHID SIDDIQI (Embry-Riddle Aeronautical University, Daytona Beach, FL) and RICHARD E. NEATE (Maharishi International University, Fairfield, IA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 7 p.
(AIAA PAPER 86-9820)

Tests and flight techniques utilized in the Embry Riddle Aeronautical University In-Flight Laboratory course are described. The aircraft used in the course is a Cessna 172 instrumented for taking four channels of data. The tests evaluate the performance, stability, and maneuverability of the aircraft and require about 12 hours of flight time. The eight tests include the: (1) pressure instrument test, (2) weight specific excess power test, (3) level flight performance test, (4) V-n diagram aerodynamic envelope, (5) stick fixed and free neutral points determination, (6) maneuvering stability neutral points, (7) L/D flight test, and (8) phugoid dynamic stability flight test. Proposals for expanding the In-Flight Laboratory course are discussed. I.F.

A87-23264
AIR WORTHY
J. W. E. STORM VANS GRAVESANDE, ED. and A. VAN DER VEEN VONK, ED. Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, 313 p. For individual items see A87-23265 to A87-23275.

The present conference on aviation law-related topics discusses new aviation legislation for Indonesia, the administrative regulation of aircraft model sports in the Netherlands, responsibility in civil and military aviation administration under German law, the political influence exerted by remote sensing, the destruction of KAL flight KE007 in light of Article 3 bis of the Chicago Convention, and the use of licensing as an instrument of deregulation. Also discussed are the deregulation of air transportation in North America and Western Europe, the 1967 Outer Space Treaty's implications for the military uses of space, observations regarding the last 50 years of aircraft accident investigation in the Netherlands, the international regulation of liability in air traffic control services, and the uses of visual and oral signals between aircraft in flight to convey state-issued instructions. O.C.

A87-23268
DEREGULATION OF AIR TRANSPORT IN NORTH AMERICA AND WESTERN EUROPE
P. P. C. HAANAPPEL (McGill University, Montreal, Canada) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 89, 91-115. refs

Airline deregulation is firmly established in the United States. It is presently suggested that Canada will follow suit. On North Atlantic routes between the U.S. and a large number of ECAC nations, 'zones of reasonableness' for tariffs will remain in force for at least two years. In western Europe, EEC bodies prefer the liberalization of intra-European air transport regulations, with only the British and Dutch governments fully embracing deregulation. It is further suggested that EEC deregulation is inevitable in virture of larger trends toward lower regulation in mature air transport markets, and reductions in governmental involvement in the economy as a whole. O.C.

A87-23270
EUROCONTROL - LIABILITY AND JURISDICTION
A. E. DU PERRON (Court of Appeal, Leeuwarden, Netherlands) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 135, 137-149. refs

Six west European countries created 'Eurocontrol' in March of 1963 and entrusted it with air traffic services in the 'upper airspace' of the Flight Information regions for which each of them was responsible. In a Protocol promulgated on February 12, 1981, the Eurocontrol Convention recognized that the separation between upper and lower airspace had become impractical in view of jet aircraft operations in short range as well as long range routes. An evaluation is presently made of all other aspects of the Eurocontrol organization not affected by this Protocol. O.C.

A87-23272
THE AIRCRAFT COMMANDER IN LEGAL TURBULENCE
JACOB W. F. SUNDBERG (Stockholm, Universitet, Sweden) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 169, 171-194. refs

A discussion is presented concerning the relevance of the Tokyo Convention to the commander of Scandinavian aircraft. Under the provisions of the Tokyo Convention, the captain of a commercial aircraft landing in a state that has ratified the Convention (or when flying through its airspace) may securely assume that the state is compelled under international law to accept his competence. The Convention also obliges such a state to be accommodating when the captain is in such distress as that presented by the need to rid the aircraft of an intruder or troublemaker. There are 112 signatures to the Tokyo Convention. O.C.

A87-23273
THE INTERNATIONAL REGULATION OF LIABILITY IN THE FIELD OF AIR TRAFFIC CONTROL SERVICES
FEDERICO VIDELA ESCALADA (Buenos Aires, Universidad; Instituto Nacional de Derecho Aeronautico y Espacial, Argentina) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 195, 197-213. refs

The ICAO Legal Sub-Committee has been involved in the preparation of a draft international convention on liability arising from damages caused by air traffic control services. The present discussion notes that the liability of the operators of air traffic control services should be governed by a system comprising all operators, including the State. Persons suffering damages during the operation of flight protection services should be entitled to claim pertinent compensation from an operator; the operator's liability is extracontractual in all cases, and must have a subjective basis. The compensation for damages caused by the operation of flight protection services should, moreover, be unlimited. It is advisable to establish a system of compulsory insurance or other similar security. O.C.

A87-23274
THE 'RIGHT TO FLY' AND THE 'RIGHT TO CARRY TRAFFIC BY AIR', IN INTERNATIONAL AIR TRANSPORTATION, AFTER 40 YEARS
H. A. WASSENBERGH (Leiden, Rijksuniversiteit, Netherlands) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 215, 217-233. refs

The 'right to fly' would exist if there was effective freedom of the air, but sovereignty of States over their territorial airspace is in fact complete. This same basis of State sovereignty over national airspace is the starting point for the economic regulation of civil aviation. The present discussion of the consequences of this state of affairs in international law notes that the distinction between the different freedom categories is obsolete as an objective basis for the determination of capacity; the origin and destination of traffic being difficult to establish objectively, embarkation and disembarkation are considered to be more practical terms. O.C.

A87-23275
VISUAL AND ORAL SIGNALS BETWEEN AIRCRAFT IN FLIGHT AS A MEANS TO CONVEY INSTRUCTIONS ISSUED BY A STATE
AART A. VAN WIJK (Dutch Air Line Pilots Association, Amstelveen, Netherlands) IN: Air worthy . Deventer, Netherlands and Norwell, MA, Kluwer Law and Taxation Publishers, 1985, p. 235, 237, 239-289. refs

N87-15904# Committee on Commerce, Science, and Transportation (U. S. Senate).
NASA AUTHORIZATIONS, FISCAL YEAR 1987
Washington GPO 1987 500 p Hearings before the Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation, 99th Congress, 2d Session, 20 Mar.; 10, 16, 23 Apr.; 8 May; 5 Aug. 1986
(GPO-61-975) Avail: Subcommittee on Science, Technology and Space

NASA's FY-1987 Aeronautics and Transatmospherics Research and Technology budget requests are examined. The Advanced Turboprop Program, rotorcraft programs, the X-wing Program, long-distance supersonic cruise research, scramjet engine development, and aerospace plane technology development are addressed. M.G.

N87-16661# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
AN EXAMINATION OF BRAZIL AND THE US AS POTENTIAL PARTNERS IN A JOINT SUPERSONIC MILITARY FIGHTER AIRCRAFT CODEVELOPMENT AND PRODUCTION PROGRAM M.S. Thesis
ROCKFORD J. REINERS Sep. 1986 179 p
(AD-A174118; AFIT/GLM/LSM/86S-64) Avail: NTIS HC A09/MF A01 CSCL 05D

This thesis examines whether Brazil and the U.S. could be suitable partners in a joint supersonic military fighter aircraft program. The primary research method was a literature review accompanied by correspondence with the national aircraft corporation of Brazil, Embraer. The research was divided into seven areas for study: aircraft design factors, aircraft production factors, aircraft operation requirements, business concerns, current activities, possible future actions and Brazilian-U.S. relations. In addition, three approaches for a Brazilian supersonic fighter development were investigated: licensing, joint venture and internal development. The results of this research indicate that Brazil and the U.S. could be suitable partners for a joint supersonic fighter development program if the technology transfer and third country export requirements can be worked out to the satisfaction of both countries. Currently Brazil has approval rights for all exports of Brazilian goods containing U.S. technology. Author (GRA)

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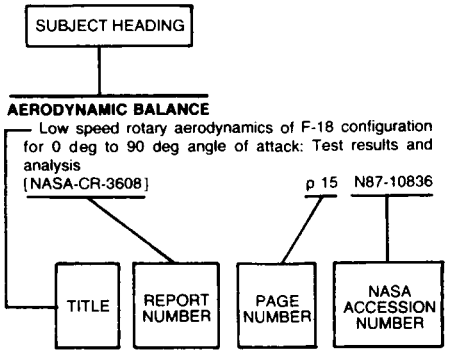

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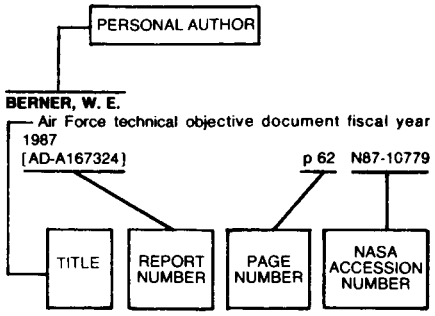

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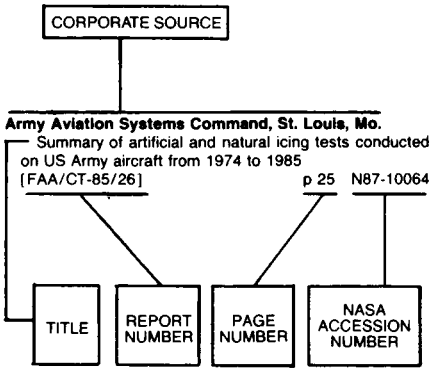

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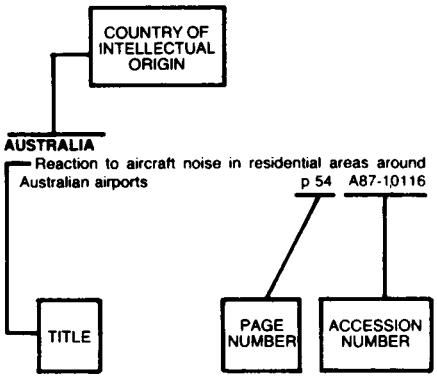

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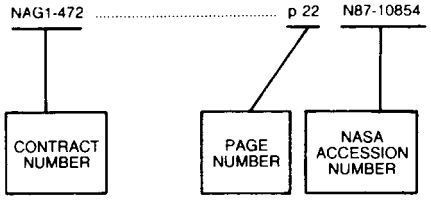

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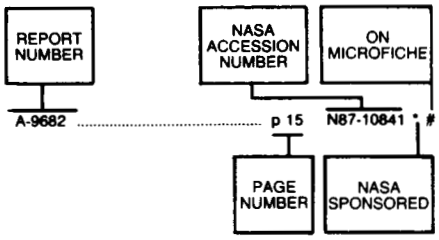

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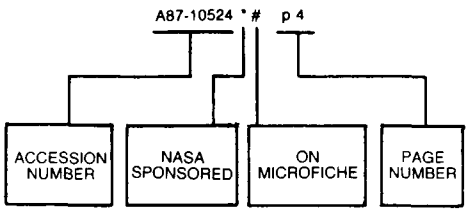

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E02	10.00	20.00
E03	11.00	22.00
E04	13.50	27.00
E05	15.50	31.00
E06	18.00	36.00
E07	20.50	41.00
E08	23.00	46.00
E09	25.50	51.00
E10	28.00	56.00
E11	30.50	61.00
E12	33.00	66.00
E13	35.50	71.00
E14	38.50	77.00
E15	42.00	84.00
E16	46.00	92.00
E17	50.00	100.00
E18	54.00	108.00
E19	60.00	120.00
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